# SHORTAGES IN SKILLED LABOR

---

## HEARING

BEFORE THE

SUBCOMMITTEE ON ECONOMIC GOALS AND
INTERGOVERNMENTAL POLICY

OF THE

JOINT ECONOMIC COMMITTEE
CONGRESS OF THE UNITED STATES

NINETY-SEVENTH CONGRESS

FIRST SESSION

NOVEMBER 3, 1981

Printed for the use of the Joint Economic Committee

U.S. GOVERNMENT PRINTING OFFICE
90-376 O WASHINGTON : 1982

J84-21

## JOINT ECONOMIC COMMITTEE

(Created pursuant to sec. 5(a) of Public Law 304, 79th Cong.)

| HOUSE OF REPRESENTATIVES | SENATE |
|---|---|
| HENRY S. REUSS, Wisconsin, *Chairman* | ROGER W. JEPSEN, Iowa, *Vice Chairman* |
| RICHARD BOLLING, Missouri | WILLIAM V. ROTH, JR., Delaware |
| LEE H. HAMILTON, Indiana | JAMES ABDNOR, South Dakota |
| GILLIS W. LONG, Louisiana | STEVEN D. SYMMS, Idaho |
| PARREN J. MITCHELL, Maryland | PAULA HAWKINS, Florida |
| FREDERICK W. RICHMOND, New York | MACK MATTINGLY, Georgia |
| CLARENCE J. BROWN, Ohio | LLOYD BENTSEN, Texas |
| MARGARET M. HECKLER, Massachusetts | WILLIAM PROXMIRE, Wisconsin |
| JOHN H. ROUSSELOT, California | EDWARD M. KENNEDY, Massachusetts |
| CHALMERS P. WYLIE, Ohio | PAUL S. SARBANES, Maryland |

JAMES K. GALBRAITH, *Executive Director*
BRUCE R. BARTLETT, *Deputy Director*

---

### SUBCOMMITTEE ON ECONOMIC GOALS AND INTERGOVERNMENTAL POLICY

| HOUSE OF REPRESENTATIVES | SENATE |
|---|---|
| LEE H. HAMILTON, Indiana, *Chairman* | LLOYD BENTSEN, Texas, *Vice Chairman* |
| RICHARD BOLLING, Missouri | PAULA HAWKINS, Florida |
|  | STEVEN D. SYMMS, Idaho |
|  | MACK MATTINGLY, Georgia |

# CONTENTS

## WITNESSES AND STATEMENTS

### TUESDAY, NOVEMBER 3, 1981

Page

Bentsen, Hon. Lloyd, vice chairman of the Subcommittee on Economic Goals and Intergovernmental Policy: Opening statement ..... 1

Willenbrock, F. Karl, Cecil H. Green Professor of Engineering, School of Engineering and Applied Science, Southern Methodist University, Dallas, Tex., on behalf of the American Electronics Association ..... 8

Weinig, Sheldon, president and chief executive officer, Materials Research Corp., Orangeburg, N.Y ..... 61

Cooper, W. Paul, chairman of the board, Acme-Cleveland Corp., chairman, Government Relations Committee, and vice chairman of the National Machine Tool Builders' Association, McLean, Va., accompanied by John Mandl, training director ..... 76

## SUBMISSIONS FOR THE RECORD

### TUESDAY, NOVEMBER 3, 1981

Cooper, W. Paul, et al.: Prepared statement ..... 81

Hawkins, Hon. Paula: Written opening statement ..... 6

Jepsen, Hon. Roger W.: Written opening statement ..... 4

National Tooling & Machining Association, the Statement of ..... 99

Rousselot, Hon. John H.: Written opening statement ..... 7

Weinig, Sheldon: Prepared statement ..... 66

Willenbrock, F. Karl: Prepared statement, together with attachments ..... 15

# SHORTAGES IN SKILLED LABOR

---

**TUESDAY, NOVEMBER 3, 1981**

Congress of the United States,
Subcommittee on Economic Goals and
Intergovernmental Policy of the
Joint Economic Committee,
*Washington, D.C.*

The subcommittee met, pursuant to notice, at 10:05 a.m., in room 6226, Dirksen Senate Office Building, Hon. Lloyd Bentsen (vice chairman of the subcommittee) presiding.

Present: Senator Bentsen.

Also present: James K. Galbraith, executive director; and George R. Tyler, Robert Premus, and William Keyes, professional staff members.

## Opening Statement of Senator Bentsen, Vice Chairman

Senator Bentsen. The subcommittee will come to order.

I recall in 1973, I asked the chairman of the Senate Finance Committee to let me form a subcommittee on capital formation. No one seemed to know what we were talking about then even though now it has become a buzzword. We were at the cutting edge of our productivity problem then and it took 8 years to see real progress in tackling that problem.

One thing I have learned in the Senate is you have to say something 44 times, or even more, before someone finally says, "Oh, by the way, did you hear what he said?" But that's the nature of this business.

I think we are on the cutting edge of another major economic problem; one that we have to address and address now. I do not think we can wait another 8 years as we did with the capital formation issue; that wait threw us too far behind in trying to do what had to be done to increase productivity and in learning the lessons of what our competitors were doing. Our Nation has begun to deal with the capital formation aspect of productivity, but we have overlooked another ingredient which is just as major and just as essential. That is the question of skilled labor in this country, the adequacy of our human skills and its role in increasing productivity.

I have made four speeches on this topic on the floor of the Senate in recent days. I intend to make a lot more to draw attention to this problem and get this country concerned about it.

According to the most recent Labor Department data, our Nation faces a shortage of 2.5 million skilled workers this decade. That's a bare minimum estimate covering only 13 occupations with the largest prospective gap between job openings and trained workers to fill those jobs. These projected shortages are in all types of occupations from service sector nurses to white collar computer systems analysis to blue collar tool and die craftsmen.

One of the most alarming aspects of this shortage is that it, in some degree, exists today. It is not a hypothetical problem we may or may not be forced to deal with next year or in 1990. It exists today hand in hand with 8 million men and women crowding into personnel offices looking for jobs, any jobs. I cannot hope to guess how many times on the stump I have heard people who have said, "The jobs are there. All you have to do is look at the classified pages. All those unemployed people have to do is go apply. Some of them just don't want to work."

What they do not realize is if you read those classified pages, almost every one of those open jobs requires some kind of skill and that is where our Nation is falling down. I think the most denigrating thing you can do to an individual is tell them they have no productive role to fulfill in our society. If you really want to turn them off, that is the way to do it.

To be out of work is a personal tragedy. But it is a national tragedy for millions of job openings to exist side-by-side with millions of unemployed. That is an indictment, a blot on our Nation that we must begin to correct. We have not learned how to train and retrain our labor force the way the Japanese and our European competitors do. I am told that the Japanese have about 40 percent of their high school students in vocational education programs. The Germans have approximately 70 percent. In our Nation, only 1 high school in 40 is a vocational one and far fewer of our high school students, than overseas, are in useful vocational programs. We have ignored the problem. In fact, it is only in recent weeks that serious attention has been paid to the prospect that shortages of skilled labor could choke efforts to rebuild our vital defense sectors.

We spend well over $30 billion a year on higher education and occupational training in this country, yet we cannot even train enough computer specialists or machinists to meet defense needs. But, the problem is much broader than just the defense sector. The administration projects a real GNP growth of 15 percent over the next 3 years. If that projection is met, that kind of heady growth would generate a major wave of inflation as hard-pressed firms frantically outbid one another for scarce computer operators and other skilled personnel already in short supply.

Many firms are dealing with today's labor shortages by diverting skilled craftsmen and technicians for on-the-job training of new workers. This diversion of skilled workers—this shadow education system—is enormous and has been a heretofore silent contributor to our lagging productivity performance and to inflation. The failure of our Nation to train sufficient technical personnel, especially compared to Japan, jeopardizes our ability to maintain foreign markets as well.

At first blush, one expects the shortage of skilled labor to exist most heavily in States like Texas and California which are growing the fastest today. But the fact that our Houston Chronicle, because of its employment classified ads, is the second or third largest seller in Detroit does not tell the whole story. Our skilled labor crisis is not a regional issue. Two jobs will be created in Texas for every one in New England during the 1980's, but that worker in Boston or Maine needs the same skills which the two need in Dallas or Houston. It is a national problem demanding national attention and requiring national answers.

This is the first hearing by the JEC on our skilled labor shortage. We will not be looking solely for answers. We are seeking better information on where the shortages exist. We have to get a better handle on the dimensions of the problem before we effectively tackle the problem itself.

Senators Jepsen and Hawkins, and Representative Rousselot have not arrived, as yet, so I will take this opportunity to place their written opening statements in the hearing record at this point.

[The written opening statements of Senators Jepsen and Hawkins, and Representative Rousselot follow:]

## Written Opening Statement of Senator Jepsen

WHY WE ARE EXPERIENCING SUCH HIGH UNEMPLOYMENT AT THE SAME TIME THAT WE ARE WITNESSING A SHORTAGE OF SKILLED WORKERS. THE AMERICAN PEOPLE DESERVE ANSWERS. AND TODAYS HEARING SHOULD HELP US IN OUR ATTEMPT TO ANSWER THIS IRONIC QUESTION.

DOES THE PROBLEM EXIST BECAUSE WE HAVE FOCUSED ON LIBERAL ARTS EDUCATION TOO MUCH THROUGH THE YEARS, AND TECHNICAL EDUCATION TOO LITTLE?

DOES THE PROBLEM EXIST BECAUSE THE FORTY-EIGHT FEDERAL EMPLOYMENT AND TRAINING PROGRAMS ARE MISDIRECTED?

OR DO HIGH UNEMPLOYMENT AND THE SKILLED LABOR SHORTAGE EXIST SIMULTANEOUSLY BECAUSE MINIMUM AND PREVALING WAGE LAWS PREVENT MANY PEOPLE FROM MOVING INTO THE LABOR FORCE IN THE FIRST PLACE AND THEREBY PREVENT ON-THE-JOB TRAINING FOR SKILLED LABOR POSITIONS?

IT IS IMPORTANT THAT WE GET ANSWERS TO THESE QUESTIONS. IT MAY BE EVEN MORE IMPORTANT THAT WE RECEIVE INFORMATION WHICH WILL HELP US IN OUR CONSIDERATION OF A SOLUTION TO OUR LABOR PROBLEMS.

CERTAINLY PUBLIC POLICY NEEDS TO BE ASSESSED AND REDIRECTED. THE PERCENTAGE OF GROSS NATIONAL PRODUCT WHICH WAS DEVOTED TO FEDERAL EMPLOYMENT AND TRAINING PROGRAMS HAS GROWN FROM 0.34 PERCENT IN 1974 TO 0.55 PERCENT LAST YEAR. YET, UNEMPLOYMENT HAS WORSENED. WE HAVE $14 BILLION WORTH OF EMPLOYMENT AND TRAINING PROGRAMS FUNDED UNDER PRACTICALLY EVERY MAJOR AGENCY OF THE FEDERAL GOVERNMENT. YET, WE SUFFER FROM A SHORTAGE OF SKILLED WORKERS.

I TRUST TODAY'S HEARING WILL HELP US TO GET A HANDLE ON THIS PROBLEM.

## WRITTEN OPENING STATEMENT OF SENATOR HAWKINS

THE NEED FOR INNOVATIVE APPROACHES TO DEFENSE MANPOWER PLANNING IS PARAMOUNT. POSSIBLE BOTTLENECKS IN THE SUPPLY OF SKILLED RATINGS, TECHNICAL PERSONNEL, ENGINEERS AND SCIENTISTS, IN AMERICA'S ARMED FORCES CALL FOR NEW MANPOWER STRATEGIES.

AS IN OTHER LABOR MARKET AREAS, THE GOVERNMENT MUST FOSTER THE EFFICIENT WORKING OF THE MARKET ECONOMY. IN THE DEFENSE MANPOWER AREA ARTIFICIAL CONTROLS AND BARRIERS MUST BE REDUCED. TO ILLUSTRATE, THIS COULD MEAN ALLOWING SO-CALLED "LATERAL RE-ENTRY" OF FORMER ARMED SERVICES PERSONNEL WHO HAVE JOINED THE RANKS OF SKILLED CIVILIAN WORKERS AS, FOR EXAMPLE, COMPUTER SPECIALISTS, BACK INTO OUR ARMED SERVICES.

ANOTHER BARRIER THAT COULD BE REMOVED IS THE BARRIER TO "LATERAL TRANSFERS" BETWEEN THE SERVICES. IN OTHER WORDS, PERSONNEL NEED TO HAVE THE FLEXIBILITY TO MOVE FROM ONE BRANCH OF THE SERVICES TO WHERE THEY ARE NEEDED IN ANOTHER BRANCH.

BOTH THESE SUGGESTIONS REQUIRE CAREFUL STUDY; AMONG OTHER THINGS, WE WOULD NEED TO KNOW THE LIKELY EFFECTS OF SUCH ACTIONS ON THE CIVILIAN LABOR MARKET. BUT I BELIEVE THEY MERIT CLOSE ATTENTION.

THANK YOU.

## WRITTEN OPENING STATEMENT OF REPRESENTATIVE ROUSSELOT

America needs more skilled labor. Public education can help give us a start on this goal by providing students with the ability to read and write. But beyond that a basic science curriculum is critical for the development of new technologies and production methods. Furthermore, an understanding of culture, language, and human interest is necessary to market products in other lands.

Jobs are a continuous learning experience, and skill training and upgrading of our labor force are important if America is to meet the compétititive challenges of the future. "Learning by doing," "hands on experience," and "employee development" are not just buzzwords to attract potential employees but are crucial to an increase in productivity and output.

The minimum wage, however, is depriving unskilled labor of the opportunity to enter the labor market. The door to business and further development is closed to youth who can not convince employers that they are worth at least the minimum wage.

I am pleased that these hearings are being held. Over the last few years we have raised the public awareness of the need for increased capital formation. Now we must do the same for the important corrollary -- a more skilled labor force. Together these two developments will increase productivity and will bring rising living standards to all Americans.

Senator **Bentsen**. Our witnesses today are F. Karl Willenbrock. Cecil H. Green professor of engineering at Southern Methodist University in Dallas, who is appearing on behalf of the American Electronics Association; Sheldon Weinig, president of Materials Research Corp. of Orangeburg, N.Y., and W. Paul Cooper, vice chairman of the board of the National Machine Tool Builders' Association. Welcome, gentlemen.

Mr. Willenbrock, we will start with your testimony, please.

## STATEMENT OF F. KARL WILLENBROCK, CECIL H. GREEN PROFESSOR OF ENGINEERING, SCHOOL OF ENGINEERING AND APPLIED SCIENCE, SOUTHERN METHODIST UNIVERSITY, DALLAS, TEX., ON BEHALF OF THE AMERICAN ELECTRONICS ASSOCIATION

Mr. **Willenbrock**. Thank you, Mr. Vice Chairman. My name is F. Karl Willenbrock. I am Cecil H. Green professor of engineering at Southern Methodist University in Dallas, Tex.

I have a brief biographical sketch which indicates my activities in engineering education, engineering practice, and engineering professional societies. For 6 years I was Director of the Institute for Applied Technology of the National Bureau of Standards; I have also served as a consultant to many industrial companies.

I am appearing before you this morning on behalf of the American Electronics Association. AEA is a trade association of more than 1,500 electronics companies in 43 States. The members manufacture electronics components and systems or supply products and services in the information processing industries. While their companies employ more than a million Americans and include some of the Nation's largest companies, more than half of the association's members are small companies that employ fewer than 200 people.

I am a member of AEA's Blue Ribbon Committee on Engineering Education, chaired by William J. Perry, former U.S. Under Secretary of Defense for Research and Engineering. The members of this committee are attached to my prepared statement along with an AEA document entitled "Planting the Engineering Seed Corn" which, with your permission, I am submitting these for the record as part of my testimony.

Senator **Bentsen**. Without objection, it is so ordered.

Mr. **Willenbrock**. Thank you.

Mr. Vice Chairman, as you know, electronics is one of America's most economically important high technology industries. Growing at a phenomenal annual rate of 17 percent for the last 10 years, electronics companies now have total sales of $200 billion and employ 1.5 million people. Electronics, on which both computer and communications systems are based, is part of the information technology sector which alone accounts for 45 percent of the GNP.

I am pleased to be able to testify on AEA's behalf today, as I share their concern over the growing shortage of skilled labor—especially of engineers and technicians—which threatens the electronics industry's ability to continue to grow, and which also erodes our country's ability to remain at the forefront of many technologies.

As the Nation's largest association of electronics companies, AEA is deeply concerned about the shortage of technicial personnel. Its board of directors appointed a blue ribbon committee to study the availability of technical personnel, determine the extent and causes of the perceived shortage, and recommend a plan for industry action to remedy it. Toward this end, AEA conducted a national survey of its members, asking them to project their technical workforce needs in 21 job categories through 1985.

Data were received from 671 respondents to the AEA questionnaire. The participating companies reflect a broad cross section of the electronics industry by product line, company size, annual sales, and geographical distribution. The respondents represent approximately a half million employees and a combined annual sales volume of approximately $77.7 billion. This sample is representative of the entire U.S. electronics industry. The 671 respondents, roughly one-third the entire industry, project a need over the next 5 years for; an additional 113,098 technical professionals in eight job categories, an average of 168 per respondent and an increase over current staff of 76 percent; an additional 140,002 technical paraprofessionals in 13 job categories, an average of 208 per respondent and an increase over current staff of 102 percent.

The projected percentage growth in each of the 21 job categories is detailed on a chart from a 200-page report entitled "Technical Employment Projections, 1981–1983–1985," which gives the details of the survey made. A copy of the report has been supplied to the staff of the subcommittee.

Extrapolating the collected data to the entire electronics industry and focusing on the electrical and computer science areas shows a projected demand for some 199,000 new electrical and computer science engineers by 1985. However, the projections through 1985 for degrees to be awarded in these two fields from all U.S. colleges and universities indicate some 70,000 new bachelor of science electrical and computer science graduates. The shortfall between supply and demand of bachelor of science electrical and computer science projects to 129,000 or 25,000 annually. To meet just the needs of electronics industry alone, the engineering schools would have to triple their output of EE and CS engineers each year for the next 5 years. This statement does not take into account the needs of other engineering-intensive industries.

It is apparent that no such dramatic increase will occur. In some cases leading engineering schools are decreasing their enrollments because they do not feel they can provide their students with an educational experience of adequate quality. In other schools, students are being delayed in their completion of the 4-year program, because they are not able to obtain entry into required courses with the result that a longer time is needed to complete a baccalaureate degree program.

Engineering shortages pose a particular dilemma for defense contractors. When the President was asked recently by reporters where companies would find technical workers if the defense budget passes, his optimistic reply was "give industry the money and it will find the people." Yet to win defense dollars company proposals must demonstrate that competent technical talent is already on board or "at hand." A lack of engineers prevents many companies from bidding altogether.

Companies which now have defense contracts are experiencing difficulty in staffing existing vacancies. The Department of Defense has great difficulty in hiring and retaining civilian as well as military engineers. According to the Wall Street Journal, the Pentagon recently announced that "because of a shortage of engineers at Vandenburg Air Force Base in California, there will be a 14-month delay in launching the first military payloads aboard the Space Shuttle."

Japan produces 163 engineering graduates per million population, and the Soviet Union 260 per million. The United States produces only 67 per million—actually dropping from production of 88 per million in 1970. Comparisons with the U.S.S.R. are difficult because of the differences between the U.S.S.R. and the U.S. educational systems. However, an SRI international report, referenced in the attached document, entitled "The Education and Employment of Scientists and Engineers in the United States and U.S.S.R." by Katherine P. Ailes and Franchis W. Rushing, published May 1981, concludes that although the United States has nearly three times the number of students enrolled in higher educational institutions, the Soviet Union graduates almost six times as many technical specialists at the undergraduate level as does the United States.

In the U.S.S.R. it is probable that there is inferior instruction with respect to approximately one-third of the engineering graduates who are enrolled on a part-time basis. It should also be noted that approximately 70 percent of the Soviet graduate students are enrolled in science and engineering fields. This compares to U.S. science and engineering enrollments of approximately 20 percent in 1976, of which only one-quarter are in engineering.

Japan has approximately half the population base of the United States. Yet the Japanese universities graduate more engineering students at the baccalaureate level than the United States. This disparity is particularly noteworthy in the area of electronics where the Japanese are graduating almost 4,000 more engineers a year than the United States and are sharply increasing their rate of production. In view of the plan of the Japanese Ministry of International Trade and Industry [MITI] to concentrate a major effort in computers, this disparity is of particular concern to the AEA member companies which include most of the major computer manufacturers.

However, there are a number of positive statements that can be made about the future supply of engineering talent in the United States. The most positive is that the demand for engineering education at the undergraduate level in engineering schools throughout the United States is higher now than it ever has been and is still increasing.

Most engineering schools also report that the quality of students requesting engineering education is higher than it ever has been. An important feature of this demand is that there is the large increase in the number of women students. Some schools report that 20 to 25 percent of their freshman classes are women. This is a remarkable change. The percentage of women among the Nation's more than 1 million engineers is of the order of 1 percent. Since the United States has a smaller percentage of women engineers than most of the other industrialized countries except Japan, it is now in the process of catching up. There is also a growing number of minority students taking engineering.

The shortage of engineering talent in the United States does not stem primarily from a lack of students, but rather with the shortage of educational resources to educate them. The colleges of engineering are accommodating increasing numbers of students, but the shortage of engineering faculty—some 2,000 to 2,500 faculty positions are open or 10 to 15 percent of the total—is causing some schools to cut enrollments to hold down the student-to-faculty ratios. In addition to the faculty shortage, engineering schools also lack up-to-date laboratory equipment. Much laboratory equipment in current use is 30 to 50 years old. A deep concern exists among engineering educators about the effect of too little, too old laboratory facilities on the quality of their educational programs. Engineering education requires a balance between analytical and experimental instruction.

If I may interpolate in my remarks, Mr. Vice Chairman, I recently learned that the Accreditation Board for Engineering and Technology, which is a nationally recognized accreditation body for all engineering colleges in the United States has noted a significant deterioration of quality during the last accreditation cycle. They accredit on a yearly cycle. In last year's cycle, approximately 50 percent of the schools obtained full 6-year accreditation for their programs. Previously 6-year accreditation has been up to 70 percent. So the deterioration is being demonstrated by the fact that the accreditation teams are finding that the programs are not up to previous standards. Another fact is that there have been a larger number of programs than ever before that have been not accredited or have been assigned a "show cause" action which indicates they will lose their accreditation in 3 years unless very significant improvements are made.

So the concern about quality is not only something that the engineering educators are talking about. Rather quality deterioration is showing up in the accreditation process; this is a very serious indication of a problem that is being faced by the engineering schools today.

Returning now to the my prepared statement, the faculty shortage is the most serious problem. It is primarily caused by low academic salaries compared to industry, by outdated, scarce equipment and facilities, and by insufficient external research support. But the teaching shortage is compounded by the sharp decrease in the number of U.S. post-baccalaureate students undertaking graduate work in engineering. Increasingly, U.S. engineering students are stopping their formal education after the B.S. degree. Faced with attractive industrial job offers in contrast to few low-paying graduate fellowships, students lack the incentives to pursue a Ph. D. to become a future faculty member. According to the American Association of Engineering Societies' Manpower Commission there were 490 fewer MS/EE's awarded in 1980 than in 1970, a decrease of 11.8 percent. There were 356 fewer Ph. D./EE's awarded in 1980 than in 1970, a decrease of 40 percent.

Furthermore, according to the AAES, engineering graduate student ranks are increasingly swelled by foreign students. In 1980, 46.3 percent of all engineering graduate students were foreign students. Of the foreign students who received Ph. D. electrical engineering degrees last year, 66 percent were on student visas.

Senator **Bentsen**. How does that compare with other countries? You say that 46 percent of all the engineering graduate students in our country earning their Ph. D. are foreign nationals on student visas, and that most of them go home. How does that compare with the engineering schools of other countries?

Mr. **Willenbrock.** It would vary widely from country to country. In Japan I would expect there would be relatively few foreign students. There's a language barrier. The most popular engineering graduate schools are determined by the language. English is the language of science and technology, so the engineering schools in the United States, Canada, and England would have relatively large foreign student enrollments. In England there's been a very significant decrease recently since the Thatcher government has raised the tuition very significantly for foreign students. Some are coming to the United States now, because it's less expensive to complete their graduate education here.

In Germany and in Swiss universities, there are also large foreign student populations. I can't specify other countries. I would say that the United States probably has the largest number. We are very effective exporters of some of our engineering knowledge this way.

Senator **Bentsen.** Maybe we ought to be raising the tuition a bit ourselves for the foreign students?

Mr. **Willenbrock.** That's one thing to do. As you know, in most State unversities you can establish residence in a State after 1 year, and resident tuition in most State universities is extremely low. So, actually, the tuition is not a barrier. Living cost is a lot more expensive.

Most engineering educators feel, however, it is not the increase in the foreign students, it's rather the decrease in the American students that's the real problem. The percentages of foreign students has gone up because the American students are decreasing in number. Educators would much prefer to solve the problem by an increase in U.S. graduate students.

At the graduate level, the industrial job attractiveness is high. In essence, the student faces the alternative of a $25,000 a year job or $5,000 a year fellowship. It's pretty easy to select the industrial position, particularly if you're allowed to get a master's degree on a part-time basis at full salary which many companies allow. Industrial companies have made their positions very attractive, and the universities just can't keep up with it.

Based on a University of California Davis study which is detailed on page 21 of the attachment entitled "Planting the Engineering Seed Corn," the projected need for new engineering faculty members—including positions for expansion and replacements—requires the addition of approximately 1,000 new professors per year through the next decade. Yet there will be an annual shortfall of approximately 50 percent, because as well as finding it very difficult to compete with industry at the baccalaureate level, at the Ph. D. level the competition is also extremely strong. The result is that most American graduate students with a Ph. D. degree go to industry and relatively a decreasing percentage are accepting academic positions.

Now turning to what the companies are doing to combat the shortage, in recent years electronics companies have been scrambling for technical talent. The shortages of engineers and technicians in particular, have driven up the cost of doing business. In many cases, companies outbid one another for the services of an engineer. Loral Electronics, for example, pays $5,000 for referral of an engineer with 4 years' experience. Three Lockheed divisions pay employees $1,000 for each engineer they refer for possible employment.

Small companies, unable to offer perquisites of tennis courts and jogging tracks or to spend huge sums on media-splash advertising and recruitment campaigns as some big companies do, are severely disadvantaged. Since innovation and accelerated job growth so frequently come from small companies, the effect on them of long-term shortages is of special concern.

Senator **Bentsen**. I have tried to help resolve that problem by restoring some of the advantages of stock options so that these small companies could compete in attracting some of these people from the larger companies.

Mr. **Willenbrock**. Yes, sir, your efforts in that direction are well-recognized and well-appreciated. Small companies are very happy about it. I've talked to quite a few companies whose executives feel through stock options they can compete effectively with the large companies which have many other advantages.

The competition for technical people has created a job-hopping mentality of technical personnel that is reflected in a high turnover rate—overall more than 25 percent in the electronics industry. In several regions of the country such as California, high-priced housing exacerbates recruitment from other areas and turnover rates escalate. In Orange County AEA's 1981 Benchmark survey documented an annual turnover of the entire work force at 41.5 percent; in Santa Barbara, 38.4 percent.

AEA is undertaking an aggressive program to increase the availability of technical personnel. The nine-point plan, recently approved by the AEA board of directors, is included in the attachment referred to earlier. It calls for an industrywide standard annual contribution to engineering colleges equivalent to 2 percent of each company's R. & D. expenditures. These contributions in the form of cash grants for graduate fellowships to encourage students to enter teaching, for equipment and facilities, et cetera, are expected to produce $30 to $50 million annually for engineering education.

AEA is also forming Industry Electronics Education Committees on a regional basis. With the assistance of loaned executives, these committees will focus on activities such as providing industry employees to serve as part-time faculty members and encouraging companies to give sabbaticals so their engineers can serve as full-time visiting professors.

In addition, AEA is setting up a foundation to receive and disburse funds for companies that do not wish to give directly to a college or university on their own. Legislative activity will also be initiated in selected States to strengthen the support of engineering education in publicly funded universities—especially relative to engineering faculty salaries and equipment and facilities budgets.

While we are optimistic that the AEA action program will have a positive effect on the shortage of engineering personnel, it is clear to me that a problem of this magnitude will require action on the part of the Federal Government as well. I would like to indicate my own view of some of the approaches within which solutions should be sought.

First, the connections between industry and universities in the United States should be strengthened. An undesirable side effect of the availability of Federal funding for research since World War II has been separation of the university engineering and scientific communities from those in industry. These communities have much to learn from each other.

Industrial companies can gain much mobilizing the capabilities of the faculty/graduate student research team on topics of importance to their futures just as the Federal agencies have. In turn, the academic community can gain from the problem-solving orientation of the industrial community. Various techniques such as joint research programs, industry-funded research projects, exchanges of personnel, and the joint use of equipment should be encouraged. The Federal Government, through its policies and practices, can facilitate and enhance the industry/university linkages.

Second, the National Science Foundation should strengthen its support of engineering with respect to both its research and education programs. Over the last three decades, the Foundation has developed the ability to work with and influence the programs of the Nation's universities. It should also strengthen its ties to the technology-based industrial sector whose activities relate so directly to the health of the Nation's scientific and technical enterprise. The Foundation should continue to explore new ways to encourage universities and industrial companies to combine their efforts in mutually supportive ways.

Third, the Department of Defense should take steps to strengthen the engineering education system upon which its industrial suppliers and military services depend. In its buildup of the defensive strength of the United States, the DOD is highly dependent on the availability of an adequate number of technical personnel of appropriate skills, not only in the industrial sector, but also in the military services and in the civilian work force.

I was very interested in some testimony given last month by Gen. Robert Marsh, who is the Commander of the Air Force Systems Command, before the House Science and Technology Committee. He gave some numbers which were pretty startling as to the shortages of technical personnel both in the military and civilian ranks for the Air Force. These shortages are impending their ability to accomplish the task that they have before them.

Mr. Vice Chairman, it is both through cooperative efforts, as well as the individual initiatives on the part of the industrial, academic, and governmental communities that specific means can be found for increasing the quality and quantity of the Nation's technical personnel. According to an NSF 1977 study, the high technology industries have twice the productivity, triple the real growth, six times fewer price increases, and nine times more employment gain than low technology industries. The electronics industry, a leader in high technology, is proud of its past growth and is confident that if the human technical resources are available, it can continue its rapid progress.

Thank you. I will be happy to respond to any questions you have.

Senator BENTSEN. I will have several questions, but I would like to hear the balance of the testimony first before moving to the questions.

[The prepared statement of Mr. Willenbrock, together with the attachments referred to, follows:]

## Prepared Statement of F. Karl Willenbrock

Mr. Chairman, and members of this distinguished Committee, my name is F. Karl Willenbrock. I am Cecil H. Green Professor of Engineering at Southern Methodist University.

Attached to my testimony is a breif biographical sketch which indicates my activities in engineering education, engineering practice, and engineering professional societies. For six years I was Director of the Institute of Applied Technology of the National Bureau of Standards; I have also served as a consultant to many industrial companies.

I am appearing before you this morning on behalf of the American Electronics Association. AEA is a trade Association of more than 1,500 electronics companies in 43 states. The members manufacture electronics components and systems or supply products and services in the information processing industries. While their companies employ more than a million Americans and include some of the nation's largest companies, more than half of the Association's members are small companies that employ fewer than 200 people.

I am a member of AEA's Blue Ribbon Committee on Engineering Education, chaired by Dr. William J. Perry, former U.S. Undersecretary of Defense for Research and Engineering. The members of this committee are listed at the end of my testimony along with an AEA document entitled "Planting the Engineering Seedcorn" which, with your permission I am submitting for the record as part of my testimony.

Mr. Chairman, as you know electronics is one of America's most economically important high technology industries. Growing at a phenomenal rate of 17% for the last ten years, electronics companies have total sales of $200 billion and employ 1.5 million people. Electronics, on which both computers and communications systems are based, is part of the information technology sector which alone accounts for 46% of the GNP.

I am pleased to be able to testify on AEA's behalf today, as I share their concern over the growing shortage of skilled labor--especially of engineers and technicians--which threatens the electronics industries' ability to continue to grow, and which also erodes our country's ability to remain at the forefront of many technologies.

## AEA'S SURVEY OF TECHNICAL EMPLOYMENT NEEDS

As the nation's largest association of electronics companies, AEA is deeply concerned about the shortage of technical personnel. It's Board of Directors appointed a Blue Ribbon Committee to study the availability of technical personnel, determine the extent and causes of the perceived shortage, and recommend a plan for industry action to remedy it. Towards this end, AEA conducted a national survey of its members, asking them to project their technical workforce needs in 21 job categories through 1985.

Data were received from 671 respondents to the AEA questionnaire. The participating companies reflect a broad cross-section of the electronics industry by product line, company size, annual sales, and geographical distribution. The respondents represent approximately a half million employees and a combined annual sales volume of approximately $77.7 billion. This sample is representative of the entire U.S. electronics industry. The 671 respondents, roughly one-third the entire industry, project a need over the next five years for:

- an additional 113,098 technical professionals in ~~r~~eight job categories (an average of 168 per respondent and an increase over current staff of 76%),
- an additional 140,002 technical paraprofessionals in 13 job categories (an average of 208 per respondent and an increase over current staff of 102%).

The projected percentage growth in each of the 21 job categories is detailed on the chart attached to this testimony. This chart is derived from a 200-page report entitled, "Technical Employment Projections, 1981-1983-1985," which gives the details of the survey made. A copy of the report has been supplied to the staff of the subcommittee.

Extrapolating the collected data to the entire electronics industry and focusing on the EE/CS areas shows a projected demand for some 199,000 new electrical (EE) and computer science(CS) engineers by 1985. However, the projections through 1985 for degrees to be awarded in these two fields from all U.S. colleges and universities indicate some 70,000 new BS/EE and BS/CS graduates. The shortfall between supply and demand of BS/EE & CS engineers projects to 129,000 or 25,000 annually. To meet just the needs of electronics industry alone, the engineering schools would have to triple their output of EE and CS engineers each year for the next five years. This statement does not take into account the needs of other engineering-intensive industries.

It is apparent that no such dramatic increase will occur. In some cases leading engineering schools are decreasing their enrollments because they do not feel they can provide their students with an educational experience of adequate quality. In other schools, students are being delayed in their completion of the four-year program because they are not able to obtain entry into required courses with the result that a longer time is needed to complete a baccalaureate degree program.

## DAMAGE TO THE NATION'S DEFENSE

Engineering shortages pose a particular dilemma for defense contractors. When the President was asked recently by reporters where companies would find technical workers if the defense budget passes, his optimistic reply was "give industry the money and it will find the people." Yet to win defense dollars company proposals must demonstrate that competent technical talent is already on board or "at hand." A lack of engineers prevents many companies from bidding altogether.

Companies which now have defense contracts are experiencing difficulty in staffing existing vacancies. The Department of Defense has great difficulty in hiring and retaining civilian as well as military engineers. According to the Wall Street Journal, the Pentagon recently announced that "because of a shortage of engineers at Vandenburg Air Force Base in California, there will be a fourteen month delay in launching the first military payloads aboard the space shuttle."

## TECHNICAL MANPOWER GAINS IN FOREIGN COUNTRIES

Japan produces 163 engineering graduates per million population, and the Soviet Union 260 per million. The United States produces only 67 per million--actually dropping from production of 88 per million in 1970. Comparisons with the USSR are difficult because of the differences between the USSR and the US educational systems. However an SRI international report, referenced in the attached document in May, 1981, entitled "The Education and Employment of Scientists and Engineers in the US and USSR" by Katherine P. Ailes and Francis W. Rushing concludes that although the United States has nearly three times the number of students enrolled in higher educational institutions, the Soviet Union graduates almost six times as many technical specialists at the undergraduate level as does the United States. In the USSR it is probable that there is inferior instruction with respect to approximately one-third of the engineering graduates who are enrolled on a part-time basis. It should also be noted that approximately 70% of the Soviet graduate students are enrolled in science and engineering fields. This compares to U.S. science and engineering enrollments of approximately 20% in 1976, of which only one-quarter are in engineering.

Japan has approximately half the population base of the United States. Yet the Japanese universities graduate more engineering students at the baccalaureate level than the United States. This disparity is particularly noteworthy in the area of electronics where the Japanese are graduating almost four thousand more engineers a year than the United States and are sharply increasing their rate of production. In view of the plan of the Japanese Ministry of International Trade and Industry (MITI) to concentrate a major effort in computers, this disparity is of particular concern to the AEA member companies which include most of the major computer manufacturers.

## GLIMMERS OF HOPE

However, there are a number of positive statements that can be made about the future supply of engineering talent in the United States. The most positive is that the demand for engineering education at the undergraduate level in engineering schools throughout the United States is higher now than it ever has been and is still increasing. Most engineering schools also report that the quality of students requesting engineering education is higher than it ever has been. An important feature of this demand is that there is the large increase in the number of women students. Some schools report that 20 to 25% of their freshman classes are women. This is a remarkable change. The percentage of women among the nation's more than one million engineers is of the order of 1%. Since the United States has a smaller percentage of women engineers than most of the other industrialized countries except Japan, it is now in the process of catching up. There is also a growing number of minority students taking engineering.

## CAUSES OF THE U.S. ENGINEERING PERSONNEL SHORTAGE

The shortage of engineering talent in the U.S. does not stem primarily from a lack of students but rather with the shortage of educational resources to educate them. The colleges of engineering are accommodating increasing numbers of students, but the shortage of engineering faculty--some 2,000 to 2,500 or 10%-to-15% of the total--is causing some schools to cut enrollments to hold down the student-to-faculty ratios. In addition to the faculty shortage, engineering schools also lack up-to-date laboratory equipment. Much laboratory equipment in current use is 30 to 50 years old. A deep concern exists among engineering educators about the effect of too-little, too-old laboratory facilities on the quality of their educational programs. Engineering education requires a balance between analytical and experimental instruction.

The faculty shortage is the most serious problem. It is primarily caused by low academic salaries compared to industry, by outdated, scarce equipment and facilities, and by insufficient external research support. But the teaching shortage is compounded by the sharp decrease in the number of U.S. post-baccalaureate students undertaking graduate work in engineering. Increasingly U.S. engineering students are stopping their formal education after the BS degree. Faced with attractive industrial job offers in contrast to few low-paying graduate fellowships, the incentives are lacking to pursue a Ph.D. to become a future faculty member. According to the American Association of Engineering Societies' Manpower Commission there were 490 fewer MS/EEs awarded in 1980 than in 1970, a decrease of 11.8%. There were 356 fewer PhD/EEs awarded in 1980 than in 1970 a decrease of 40%.

Furthermore, according to the AAES, the engineering graduate students ranks are increasingly swelled by foreign students. In 1980, 46.3% of all engineering graduate students were foreign students. Of the foreign students who received Ph.D/EE degrees last year, 66% were on student visas. Most of these students return to their home country.

Based on a UC Davis study which is detailed on page 21 of the attached document, the projected need for new engineering faculty members--including positions for expansion and replacements--requires the addition of approximately 1,000 new professors per year through the next decade. Yet there will be an annual shortfall of approximately 50%.

## COMPANY EFFORTS TO COMBAT THE SHORTAGE

In recent years, electronics companies have been scrambling for technical talent. The shortages of engineers and technicians in particular, have driven up the cost of doing business. In many cases, companies outbid one another for the services of an engineer. Loral Electronics, for example, pays $5,000 for referral of an engineer with four years' experience. Three Lockheed divisions pay employees $1,000 for each engineer they refer for possible employment.

Small companies, unable to offer perquisites of tennis courts and jogging tracks or to spend huge sums on media-splash advertising and recruitment campaigns as some big companies do, are severely disadvantaged. Since innovation and accelerated job growth so frequently come from small companies, the effect on them of long-term shortages is of special concern. The competition for technical people has created a job-hopping mentality of technical personnel that is reflected in a high turnover rate--overall more than 25% in the electronics industry. In several regions of the country such as California high-priced housing exacerbates recruitment from other areas and turnover rates escalate. In Orange County AEA's 1981 Benchmark survey documented an annual turnover of the entire workforce at 41.5%; in Santa Barbara, 38.4%.

## AEA's PROGRAM TO COMBAT THE SHORTAGE

AEA is undertaking an agressive program to increase the availability of technical personnel. The 9-point plan, recently approved by the AEA Board of Directors, is included in the document attached. It calls for an industry wide standard annual contribution to engineering colleges equivalent to 2% of each company's R&D expenditures. These contributions in the form of cash grants for graduate fellowships to encourage students to enter teaching, for equipment and facilities, etc. are expected to produce $30 to $50 million annually to engineering education.

AEA is also forming Industry Electronics Education Committees on a regional basis. With the assistance of loaned executives, these Committees will focus on activities, such as providing industry employees to serve as part-time faculty members and encouraging companies to give sabbaticals so their engineers can serve as full-time visiting professors.

In addition, AEA is setting up a foundation to receive and disburse funds for companies that do not wish to give directly to a college or university on their own. Legislative activity will also be initiated in selected states to strengthen the support of engineering education in publicly funded universities--especially relative to engineering faculty salaries and equipment and facilities budgets.

## POSSIBLE SOLUTIONS AT THE FEDERAL LEVEL

While we are optimistic that the AEA action program will have a positive effect on the shortage of engineering personnel, it is clear to me that a problem of this magnitude will require action on the part of the federal government as well. I would like to indicate my own view of some of the approaches within which solutions should be sought.

First, the connections between industry and universities in the U.S. should be strengthened. An undesirable side-effect of the availability of federal funding for research since World War II has been a separation of the university engineering and scientific communities from those in industry. These communities have much to learn from each other. Industrial companies can gain much by mobilizing the capabilities of the faculty/graduate student research team on topics of importance to their futures just as the federal agencies have. In turn, the academic community can gain from the problem-solving orientation of the industrial community. Various techniques such as joint research programs, industry-funded research projects, exchanges of personnel, and the joint use of equipment should be encouraged. The Federal Government, through its policies and practices, can facilitate and enhance the industry university linkages.

Second, The National Science Foundation should strengthen its support of engineering with respect to both its research and education programs. Over the last three decades the Foundation has developed the ability to work with and influence the programs of the nation's universities. It should also strengthen its ties to the technology-based industrial sector whose activities relate so directly to the health of the nation's scientific and and technical enterprise. The Foundation should continue to explore new ways to encourage universities and industrial companies to combine their efforts in mutually supportive ways.

Third, the Department of Defense should take steps to strengthen the engineering education system upon which its industrial suppliers and military services depend. In its build-up of the defensive strength of the United States, the DOD is highly dependent on the availability of an adequate number of technical personnel of appropriate skills, not only in the industrial sector, but also in the military services and in the civilian work force.

Mr. Chairman, it is both through the cooperative efforts, as well as the individual initiatives on the part of the industrial, academic, and governmental communities that specific means can be found for increasing the quality and quantity of the nation's technical personnel. According to a 1977 study, the high technology industries have twice the productivity, triple the real growth, six times fewer price increases, and nine times more employment, than low technology industries. The electronics industry, a leader in high technology, is proud of its past growth and is confident that if the human technical resources are available, it can continue its rapid progress.

Thank you. I will be happy to respond to any questions you have.

Attachments.

**American Electronics Association**
Government Operations Office

1612 K Street N.W.
Washington, D.C. 20006

(202) 659-9416

AEA BLUE RIBBON COMMITTEE ON ENGINEERING EDUCATION

Committee Chairman
Dr. William J. Perry, Partner
Hambrecht and Quist

Dr. Richard Atkinson, Chancellor
University of California, San Diego

Dr. Joseph A. Boyd, Chairman of the Board and Chief Executive Officer
Harris Corporation

John M. Fluke, Chairman
John Fluke Manufacturing Company, Inc.

Dr. C. Lester Hogan, Director and Consultant
Fairchild Camera and Instrument Corporation

Dr. Robert N. Noyce, Vice Chairman
Intel Corporation

Dr. Joseph Pettit, President
Georgia Institute of Technology

Dr. Allen E. Puckett, Chairman
Hughes Aircraft

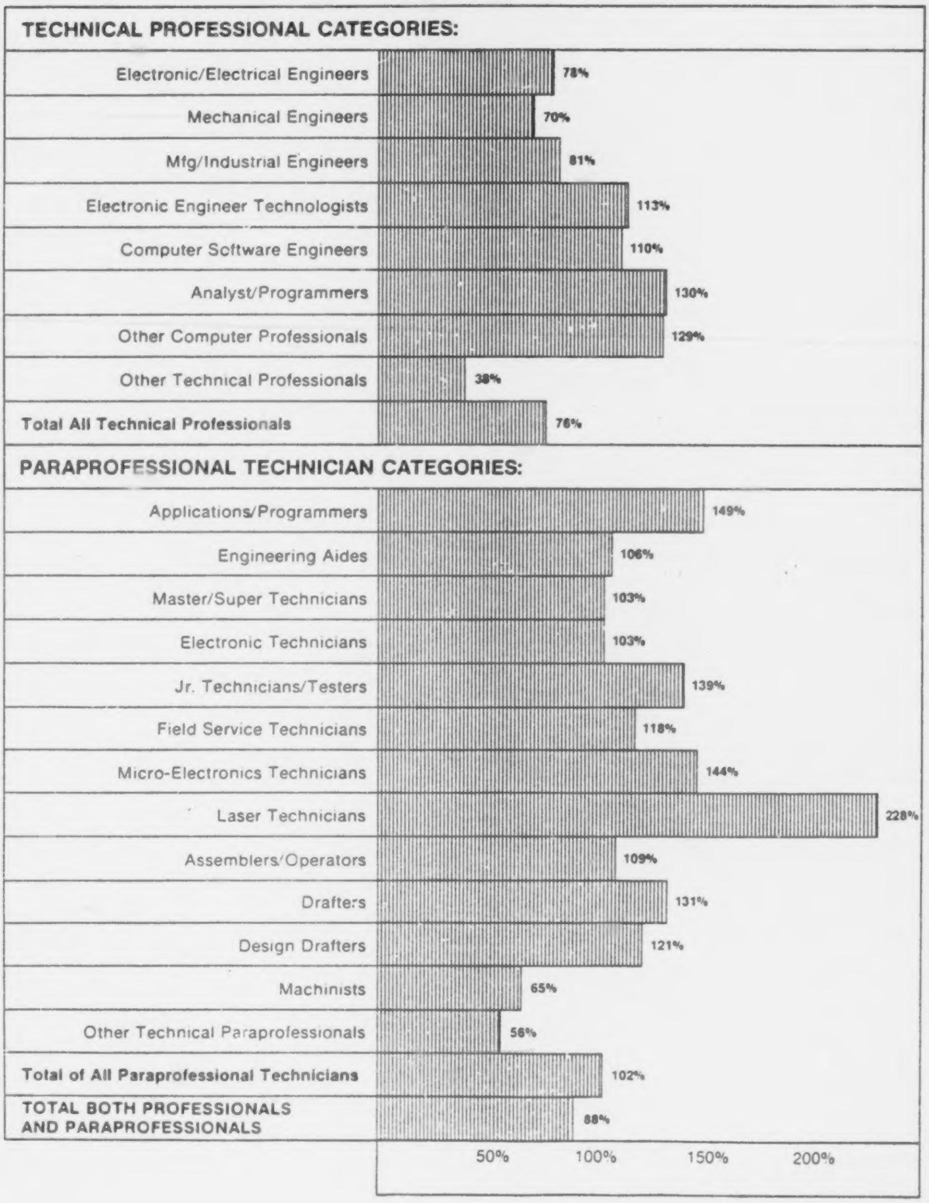
Ray Stata, Chairman and President
Analog Devices, Inc.

Dr. Dean A. Watkins, Chairman
Watkins-Johnson Company

Dr. Karl Willenbrock, Green Professor of Engineering
Southern Methodist University

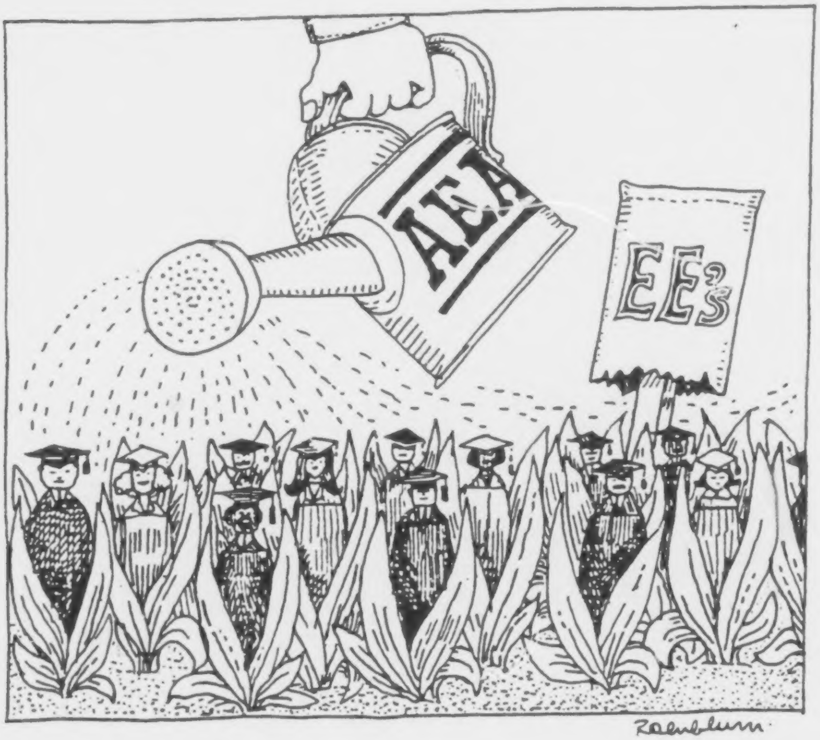
John A. Young, President and Chief Executive Officer
Hewlett-Packard Company

## UNITED STATES: AEA DATA ONLY
## Projected Growth as Percentage of Total
## 1981-1985



# Planting The Engineering Seed Corn

*"Academicians compare industry's appetite for BSE graduates to that of starving American Indians of long ago who, to survive the winter, ate the seed corn needed to plant next year's crop."*



## INTRODUCTION

The American Electronics Association's 1981 Board of Directors appointed a select group of industry executives and educational leaders to a Blue Ribbon Committee on Engineering Education. The committee's charge has been to study the problem of engineer shortages, certify its existence and degree, identify the major barriers, and recommend a plan for Association action.

On September 15, 1981, AEA's Board approved the following nine-point plan for both short- and long-term redress. A white paper, which outlines the significance of the problem and points toward major causes, is included to provide a philosophical framework to view the direction of remedy the Association will take.

Because of the changing nature of the problem, industry will need to work to solve it for the "long haul." Other areas will clearly need attention down the way. For example, although an adequate supply of qualified engineering students now exists, changing demographics will cause a reduction in the applicant pool and a change in its composition to include more females and minorities and fewer white males. Increased career counseling and math and science "outreach" programs, therefore, will need to be aimed at females and minority high school students. Moreover, the increasing shortage of math and science teachers at the secondary school level, already at a danger point, will predictably reach crisis stage if something does not turn it around soon.

There is engineering seed corn still in the U.S. silos. The electronics industries just need to make a decision to pay the high cost to buy and plant it.

Pat Hill Hubbard, Manager
Engineering Education

One of America's fastest-growing and most economically-prized high technology industries is electronics. Young and dynamic, electronics has had a phenomenal annual growth rate of 17 percent during the past decade.[1] Sales of electronic products by 100 of the major companies reached $152 billion in 1980,[2] bringing the total sales for the larger industry close to $200 billion. A 1981 Panel on Computing and Higher Education quotes a Commerce Department report that says information technology accounts for 46% of the GNP, and computer sales alone bring a $6 billion balance of trade surplus.[3]

The promise of electronics to continue improving the quality of life is threatened by the growing shortage of computer software (CS) and electrical/electronic (EE) engineers. Like critical pieces of technological DNA, engineers are the building blocks of electronics.

## I

## AEA ENGINEERING EDUCATION PROGRAM

PROGRAM GOAL: To significantly increase the quantity of engineers while maintaining educational quality.

Problem Statement: An increasing national shortage of engineers threatens to limit the growth of high technology and negatively impact the economic and political leadership of the United States, as well as the continued health and expansion of the electronics industries.

Extent of the Problem: A shortfall exists between supply of engineering graduates and projected industry demands for engineers. The shortfall for the electronics industries alone projects to 25,000 EE/CS baccalaureate engineers annually through 1985. Engineering colleges will need to step up output immediately to meet the needs.

Causes of the Problem at the Undergraduate Level: The shortage of BS degrees is primarily due to a lack of resources, especially faculty, of engineering colleges to handle the oversupply of qualified students.

> Degree of Undergraduate Problem: Roughly, only 1 of every 3 qualified applicants is admitted to undergraduate engineering programs because of limited resources. Enrollments, while up 7.2% from a year ago, are straining educational capacity, threatening the quality of education, and lessening the attractiveness of teaching as a career. In response, many colleges are limiting or contracting enrollments, raising admissions requirements, increasing class sizes, etc.

- o Laboratory equipment, now 20 to 30 years old, is outdated and in short supply; little is available to teach "new technologies."
- o Lab and classroom facilities need upgrading and are in short supply; increased numbers of students will create extra "wear and tear."

- 10%-to-15% or 2,000 to 2,500 engineering faculty positions are unfilled. Faculty vacancies are nearly 50% in solid-state electronics, computer engineering, and digital systems. Faculty shortages make teaching unattractive (larger classes, longer hours) and affect educational quality.

Causes of the Problem at the Graduate Level: The shortage of MS and Ph.D degrees awarded to U.S. citizens is due to an undersupply of graduate students. After the BS degree students are attracted to jobs with high starting salaries in industry. Incentives to become faculty members (requiring Ph.D) are poor.

Degree of Graduate Problem: 400 fewer MS/EE degrees were granted in 1980 (total of 3,740) than in 1970 (total of 4,150). 350 fewer Ph.D/EE degrees were granted in 1980 (total of 532) than in 1970 (total of 873).

U.S. citizens received 76.5% or 2,859 MS/EEs awarded in 1980.
U.S. citizens received 67.4% or 352 Ph.D/EEs awarded in 1980.

- Rising tuition costs, low graduate assistance salaries, fewer graduate fellowships, and inadequate facilities make BS-level industry salaries much more attractive than graduate study.
- There are actual disincentives to pursuing the education required for a faculty career: low academia salaries compared to industry's, high student-to-faculty ratios, poor quality research and teaching equipment, difficulty in gaining external research funding, etc.

What Needs To Be Done:

Short-term: Add resources to immediately expand educational capacity.

Long-term: Add resources to increase the number of Ph.Ds (to do advanced industry research and to become faculty for tomorrow's students) and enhance the quality of engineering education.

What AEA Can Do

I. Expanded educational resources

   A. Increase faculty
      - AEA adjunct and visiting professors
      - AEA teaching "chairs"
      - AEA industry consultancies (salary supplements for new faculty)
      - Legislative action to increase engineering and computer science faculty salaries (public universities)

   B. Increase and upgrade equipment and facilities
      - AEA grants
      - AEA equipment transfers
      - Legislative action to increase equipment/facilities budgets (public universities)

II. Increase graduate student supply (more Ph.Ds)

   A. AEA graduate student fellowships

   B. AEA co-op programs

How AEA Can Do It (Mechanisms):

1. Set an industry-wide standard for giving resources to education: 2% of a company's R&D expenditures.

   Such resources can be given directly by the company to the college or through an AEA foundation. They can be given in a variety of ways: equipment, industry facilities, adjunct/visiting professors, teaching "chairs," graduate fellowships, general grants of money, etc.

2. "Spotlight" model industry-university programs to encourage companies to duplicate them.

3. Form regional task forces composed of AEA Council Engineering Education (EE) Committees to work with companies and area colleges.

   The engineering shortage is a national problem. Engineering colleges produce graduates who are employed all over the United States. The mobility question, however, is also focusing increased interest on area or regionally-located engineering institutions.

   AEA's 13 Councils provide a unique organizational structure for addressing the problem from both a local and a national standpoint. Ten states produce 58% of the BSEs (all categories). Four of these "top 10" have AEA Councils.

   Council EE Committees can work with local companies to provide industry personnel as part-time and/or full-time faculty for area universities and encourage them to provide additional resources to universities (money to fund teaching "chairs," graduate fellowships, etc.).

4. Provide assistance to the regional task forces with loaned industry executives as "facilitators."

   With assistance from AEA Engineering Education staff, loaned industry executive facilitators can assist AEA Council EE Committees in various ways, such as: (1) identify the specific needs of the universities for faculty (background, experience, specialty teaching areas, etc.); (2) help AEA member companies identify and release qualified persons to teach part-time or full-time as the need may be; (3) set up interviews for selection by the schools; (4) assist fund-raising efforts to provide salary supplements/"chairs," graduate fellowships, etc. In states targeted by AEA for legislative activity during 1982, loaned executives can assist AEA's Engineering Education and Government Affairs staffs to identify issues and generate grass-roots support as well as industry input to state governments.

5. Set up an AEA Electronics Education Foundation (EEF) to publicize and promote the Engineering Education Program (records of resources given to education, etc.); to advise and assist companies opting to directly provide resources and undertake programs (promote 1-to-1, company-to-school relationships); and to accept and disburse resources as requested.

6. Continue the Blue Ribbon Committee on Engineering Education into 1982 to complete present planning, make the federal government and the Office of the President aware of the problem and the need for supportive fiscal and tax policies to solve it, and to provide "transition" of program guidance to a Standing Committee.

7. Establish an AEA Standing Committee to provide assistance to Engineering Education staff and general guidance in achieving program goals. It will report periodically to the Board to make recommendations as appropriate.

8. Establish industry lobby-networks in major electronics states to identify and support issues which will help meet program goals (increase state budgets for equipment, etc.).

9. Increase Engineering Education Department staff with 1 full-time position to assist in program management. Staffing and additional travel to facilitate regional task force directions require an addition to current budget.

## II

## EXTENT OF THE ENGINEERING SHORTAGE

### STATEMENT OF THE PROBLEM

The growing shortage of engineers on a national scale threatens to limit the growth of high technology and negatively impact the continued health and vitality of the United States on economical, political, and social levels.

### SUPPLY AND DEMAND

The American Electronics Association's recent nation-wide survey, "Technical Employment Projections: 1981-83-85," brings hard data to certify the existence of an engineer shortage (Figure 1 is based on the survey results and indicates the severity of the problem). Note that while the SUPPLY figures are from all U.S. colleges, the DEMAND data is only from the electronics industries.

The DEMAND figures were calculated by using the survey projections as a baseline. The 671 respondents represent $77.7 billion annual sales and 500,000 employees. As this baseline represents approximately one-third of the U.S. total, the figures were multiplied by 3 and compounded annually by 4.98% to account for losses due to promotion into management.[4] The DEMAND reflects new growth only and does not include replacements due to retirement, turnover, or death.

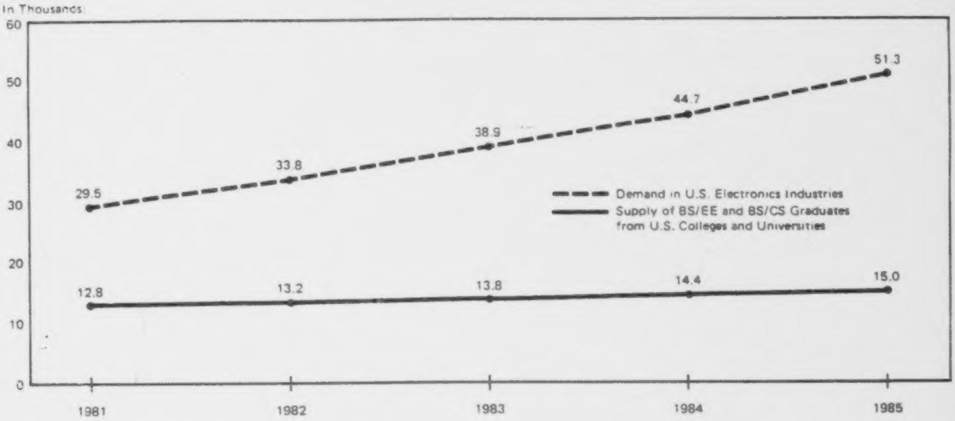
The SUPPLY figures were made by using the number of BS degrees awarded in 1980 as baseline.

The BS/EE projections were made using a 2.6% annual compounded growth rate (ACGR) projected by the U.S. Bureau of Labor.

The BS/CS degree figures were reached using a 12.4% ACGR, duplicating a pattern of 1977-to-1980 degree increases. All degree projections were reduced by 20% to account for graduates who do not take jobs in engineering.[5]

## U.S. ELECTRONICS INDUSTRIES

### COMPARISON OF PROJECTED SUPPLY AND DEMAND ELECTRICAL AND COMPUTER ENGINEERS



DATA: AMERICAN ELECTRONICS ASSOCIATION ©

Figure 1

By 1985 the electronic industries' total DEMAND for new BS/EE and CS people projects to be approximately 199,000.

By 1985, total SUPPLY of BS/EE and CS graduates projects to be around 70,000. Assuming electronics industries--to the exclusion of all other engineering-intense industries--can aggressively capture all the graduates, the SUPPLY shortfall by 1985 projects to be around 129,000 or 25,000 annually.

Just to meet the needs of electronics, education must triple its output of EE and CS engineers each year for the next five years.

Strong demands are validated by other measures as well. Deutsch, Shea, and Evans show no let-down in demand for more than three years:

| YEAR | ENGINEERING RECRUITMENT INDEX |
|---|---|
| 1978 | 139 |
| 1979 | 144 |
| 1980 | 138 |
| 1981 | 140 (Average of Jan. & Feb.) |

One Fox-Morris survey showed demand for EEs leaped 18.5% during 1980.[6] Another survey by the same group indicated the need for experienced programmers capable of writing applications software jumped 27.3% since mid-1980.[7] The American Society for Engineering Education (ASEE) estimates employers will compete heavily for 1981 engineering graduates; by diploma time, 75% with BS degrees, 73% with MS, and 92% with Ph.Ds will already have jobs.[8]

## COSTS TO INDUSTRY

In the wake of the shortage there is a scramble for technical talent which escalates the cost-of-doing-business. The price for search firm location of a $30,000 engineer can be as high as $10,000. And the practice of offering finder's fees has increased. Loral Electronics, for instance, pays $5,000 for referral of an engineer with four years experience. Three Lockheed divisions pay employees $1,000 for each engineer they refer.[9]

Small companies, unable to offer perquisites such as tennis courts and jogging tracks, and who cannot spend huge sums on media-splash advertising and recruitment campaigns are severely disadvantaged. Since innovation and accelerated job growth historically come from small companies, the effect of long-term shortages on them is of special concern.

## DEFENSE DOLLARS

Engineering shortages pose a dilemma for defense contractors. President Reagan was recently asked by the press where he thought companies would find technical workers if his defense budget passed. His optimistic reply was to "give industry the money, and it will find the people."

Yet to win defense dollars, company proposals must demonstrate that competent technical talent is already on board or "at hand." A lack of engineers prevents companies from bidding altogether. Some companies "bet-on-the-come" of a defense contract and unnecessarily stockpile people. This practice compounds the shortage problem.

Companies which now have defense contracts are experiencing difficulty in staffing existing vacancies. Rockwell, with 17,000 engineers on the payroll, is looking to hire 900 more for 1981. A company representative expressed concerns about "losing....advanced men to retirement," noting that "quality field replacements are just about impossible to come by."[10] The Pentagon just announced that "because of a shortage of engineers at Vandenberg Air Force Base in California, there will be a 14-month delay in launching the first military payloads aboard the space shuttle."[11]

With high interest rates compounding some sky-priced rental and housing markets, the old formula of moving in large numbers of people to fulfill defense contracts is no longer a given. States like California find the mobility question quite serious. AEA survey data from 313 of the state's 3,500 electronics facilities shows a need through 1985 for new EE/CS level people of 20,557 or 4,111 per year.[12] A state agency's in-house analysis of the new national defense budget's effect determined that 700,000 new jobs---half in manufacturing--are likely to be created in California by 1986 (140,000 per year). Juxtapose these DEMAND figures against the 2,909 EE/CS graduate degrees (all levels) awarded by all public and private colleges in the state in 1980, add the mobility issue, and the problem's magnitude grows.

## SOLUTION DOLLARS

Data analysis emphasizes the present shortage of engineers is likely to be exacerbated in the next few years unless industry intervenes. A study of the causes points strongly toward a money-solution.

Simply throwing a "few bucks" towards education in scattered directions brings short-term returns but may have negligible effects on the larger problem. Dollars given to colleges which lack understanding of the expanding need for engineers, whose presidents may reduce the engineering departments' budgets equal to the amount of industries' gifts, help shore up the educational system, but do not affect the problem at hand.

## III

## CAUSES OF THE ENGINEERING SHORTAGE

### STATEMENT OF THE CAUSES

Currently, the shortage in BS graduates is caused by a lack of resources--most seriously in faculty--of universities to educate the oversupply of qualified engineering graduates.

The shortage in MS and Ph.Ds is caused by an undersupply of graduate students resulting primarily from high BS-level industry salaries and disincentives to enter teaching careers, not only limiting industry's progress in advanced research, but clearly reducing the pool from which future faculty come.

### ATTITUDES

Some industry people view the cause of undergraduate engineering shortages as a misallocation of resources by university presidents. Why, they ask, don't presidents shift money from declining disciplines like English and move it to expanding ones like engineering?

Education responds to the query in several ways. Some oppose resource shifts because they consider the shortages temporary. Some are unwilling to increase engineering education budgets because of the industry's "fair-weather-friend" behavior. Some are unwilling to fight the institutional pressures involved in terminating tenured professors. And some fear increased engineering budgets will unbalance curricula and jeopardize their status as "comprehensive" universities, even when industry provides the additional monies.

Some educators look at the cause of the graduate student shortages--the pool from which future faculty come--as a result of myopic behavior by industry. Academicians compare industry's appetite for BSE graduates to that of starving American Indians of long ago who, to survive the winter, ate the seed corn needed to plant the next year's crops.

## DECLINING BIRTHRATES

If all these philosophical resistances reverse, one economic constraint remains. Declining birthrates predict a substantial decrease in post-secondary enrollments by 1990 (See Addendum A). In 1988 there will be 2,130,000 (14.3%) fewer high school students than in 1980. A decrease in college enrollments means no tuition revenue increase to pay for great shifts of student career interests.

## THE UNDERGRADUATE SUPPLY

A decade ago, engineers laid off due to space and defense program cut-backs became a media cause-célèbre. Year-long reports emphasized job losses. Rarely was the public's perspective balanced with information that the unemployment rate for engineers reached only 3.2%, staying but "a brief time before returning to its normal level of about 1%."[13] The public's long memory of the engineering "bust" coupled with Vietnam's anti-technology legacy, therefore, caused young people to avoid engineering careers for several years. This is no longer true. Engineering is the second most favored career choice of today's high school seniors (see Addendum B, Figure 1).

Estimates of the applicant-to-admission rate is placed at about 3-to-1. Dr. Joseph Pettit, President of Georgia Institute of Technology and a member of AEA's Blue Ribbon Committee on Engineering Education, states that his college approves admission for about 1,700 of the approximately 7,000 applicants. Dr. Richard Atkinson, Chancellor of UC San Diego and also a member of the AEA Blue Ribbon group, notes the high quality of today's engineering applicants and says his university, like most others, closes admissions doors the day they open. Dr. Jay Pinson, Dean of Engineering at San Jose State University, states he has "a thousand students 'holding' in other departments, waiting for engineering slots to open."

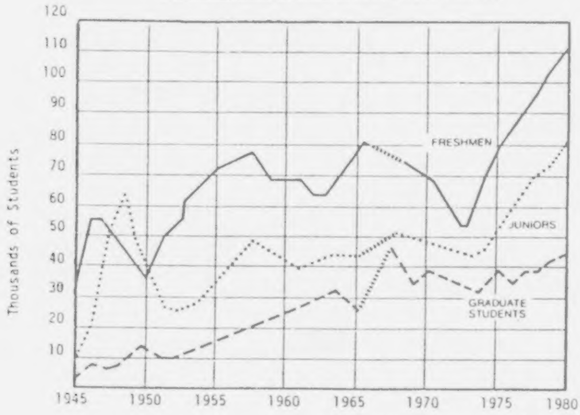
The schools have accommodated increased numbers of students. Full-time engineering undergraduate enrollments in the nation's 287 engineering colleges and universities are up 7.2% in undergraduate and 7.1% in graduate classes in fall of 1980 from a year ago. Freshmen undergraduate engineering enrollments increased 6.2% from the previous year. Females and blacks accounted for 14.1% and 5.1% respectively of the freshman class increase.

## FOREIGN STUDENTS

Some concern over increased numbers of foreign students in U.S. schools may be warranted in light of the numbers who return home after graduation and the pressure their added numbers place on already strained educational resources. In 1979, 260,000 foreign students were enrolled in postsecondary educaton (64% in public institutions). That number represents a 300% increase since 1964[14] In 1980, 6.8% of the engineering undergraduates were foreign students, while 46.3% of the engineering graduate students were foreign students. The increase of foreign students at the graduate level--from 38.7% in 1974 to the present 46.3%--does signal a need to do two things: increase the number of U.S. citizens who pursue graduate study and/or initiate federal policies which allow foreign graduates to remain in the U.S.

The recent jump in engineering enrollments at all levels, however, comes primarily from U.S. citizens--not foreign students. From 1979 to 1980 foreign student undergraduate numbers increased only 0.3% and graduate enrollments only 2.4%. Foreign students in all engineering education fields in 1980 were 40,774 or 9.4% of the total 433,451.

ENGINEERING FULL-TIME ENROLLMENTS 1945-1980



Source: Engineering Manpower Bulletin 58, May 1981
American Society of Engineering Education

## INCREASE IN UNDERGRADUATE EE AND CS DEGREES

Since 1977 when BS/EE degrees dropped to 9,837, the lowest number since 1970, there has been a steady increase in EE and CS degrees. (See Addendum B, Figure 2 for EE and CS degrees awarded 1970-1980/all levels):

| Year | BS/EEs Awarded | % of Change | BS/CSs Awarded | % of Change |
|---|---|---|---|---|
| 1970 | 11,291 | 4.80% | 139 | 167.31% |
| 1971 | 12,145 | 1.88% | 174 | 25.18% |
| 1972 | 12,430 | 2.35% | 359 | 106.32% |
| 1973 | 11,844 | -4.71% | 568 | 58.22% |
| 1974 | 11,347 | -4.20% | 727 | 27.99% |
| 1975 | 10,277 | -9.43% | 599 | -17.61% |
| 1976 | 9,954 | -3.14% | 796 | 32.89% |
| 1977 | 9,837 | -1.18% | 1,280 | 60.80% |
| 1978 | 10,702 | 8.79% | 1,546 | 20.78% |
| 1979 | 12,213 | 14.12% | 1,510 | -2.33% |
| 1980 | 13,594 | 11.31% | 1,816 | 20.26% |

2,303 more BS/EEs were awarded in 1980 than in 1970, an increase of 20.4%

## DECREASE IN GRADUATE EE AND CS DEGREES

At the graduate level the data reflects a reverse trend. 490 fewer MS/EEs were awarded in 1980 (3,660), or 11.8% less than the 4,150 in 1970. 350 fewer Ph.D/EEs were awarded in 1980, (523) or 40% less than 873 in 1970.

Comparing EE graduates of all levels in 1977 with those in 1970 on a per capita basis, a decrease is evident.

1970 88 EE graduates per one million U.S. population
1977 66 EE graduates per one million U.S. population.[15]

The sales of electronics products over the last 20 years has increased six times. The number of EE graduates has only doubled. An increase of only 5% more EE degrees at all levels has taken place during the last decade: 16,944 in 1970 versus 17,777 in 1980.

## LIMITATIONS OF EDUCATION'S CAPACITY

Some people point to the recent engineering enrollments as a sign the shortage is easing. Indeed the percentage of degreed BS/EEs has been rising for the last three years. In 1980, for example, 13,594 BS/EE degrees were awarded--an 11.3% increase over the previous year.

Assuming the 11.3% degree-growth pattern holds steady for the next five years, 94,793 BS/EE degrees would be awarded between 1981-1985. Since only 80% (75,834) is likely to enter the workforce as engineers, these numbers are still a considerable shortfall to the projected DEMAND for 199,000. (See Figure 3.)

It takes four-to-five years for an engineering student to receive a bachelor's degree. To determine the relationship between total engineering enrollments (all fields) and the number of BS/EE degrees granted requires that current degrees awarded be compared with enrollments at least four years previously. The 13,594 BS/EE degrees awarded in 1980, for example, represents 1 degree recipient to every 25 enrollees or 4.0% of the total 337,801 enrollments four years ago.

BS/EE DEGREES IN RELATION TO ENGINEERING ENROLLMENTS ALL FIELDS

| School Year | Engineering Enrollments All Fields | Enrollment Increases Over Previous Year All Fields | BS/EE Degrees Awarded/Year | Engineering Enrollments in All Fields Four Years Previously | % of BS/EE Degrees to Enrollments Four Years Previously |
|---|---|---|---|---|---|
| 1975/76 | 309,553 | 31,566 | 9,954--1976 | 270,153 | 3.7% |
| 1976/77 | 337,801 | 8,248 | 9,837--1977 | 263,003 | 3.7% |
| 1977/78 | 374,182 | 36,381 | 10,702--1978 | 277,987 | 3.8% |
| 1978/79 | 396,594 | 22,412 | 12,213--1979 | 309,553 | 3.9% |
| 1979/80 | 433,451 | 36,857 | 13,594--1980 | 337,801 | 4.0% |
| 1980/81 | 469,929 | 36,478 | [15,130--1981*] | 374,182 | see note A |
| 1981/82 | [580,450**] | [110,521**] | [16,840--1982*] | 396,594 | see note B |
| 1982/83 | [646,050**] | [65,600**] | [18,743--1983*] | 433,451 | see note C |
| 1983/84 | ......... | ......... | [20,861--1984*] | 469,929 | see note D |
| 1984/85 | ......... | ......... | [23,218--1985*] | [580,450**] | [4.0%**] |

Notes:

Brackets [ ] indicate projections.

*Degree-projections are based on 11.3% annual growth.

**Engineering enrollment projections assume continuation of the 4% relationship of BS/EE degrees to enrollments four years previously.

Note A: 15,130 degrees at a 4% relationship of degrees-to-enrollments requires enrollment four years previously to have been 378,250. The actual enrollment of 374,182 leaves a 4,068 student shortfall already.
Note B: 16,840 degrees at 4% requires enrollment of 421,000. 396,594 actual enrollment leaves 24,406 shortfall.
Note C: 18,743 degrees at 4% requires enrollment of 468,575. 433,451 actual enrollment leaves 35,124 shortfall.
Note D: 20,861 degrees at 4% requires enrollment of 521,525. 469,929 actual enrollment leaves 51,596 shortfall.

Assuming that the relationship of BS/EE degrees as a percentage of engineering enrollments in all fields continues as it has in the past few years, and taking the high point as 4.0%, enrollment will need to reach 580,450 in the coming school year in order to award 23,218 BS/EE degrees in 1985 (at 11.3% annual BS/EE growth). This will require an increase of 110,521 students. (See Figure 3.)

Unless substantially more engineering students choose electrical engineering majors or unless more who now major in it get degrees, maintaining an 11.3% annual increase of BS/EE degrees will require annual enrollment increases ranging from 65,000 to 110,000.

These increases are unlikely for two reasons. One is history. The largest enrollment increase in the past five years occurred between school years 1978/79 and 1979/80 -- 36,857. As a recent article in the Wall Street Journal notes, engineering schools are "already at capacity" and "crowded schools can't increase enrollment further....some are even cutting back."[16]

The second is demographics. Declining numbers of high school students over the next decade (see Addendum D) will reduce college enrollments, making even the present 36,000+ increase a challenge to maintain.

The strain placed on educational resources by extra numbers of students sets up a "capacity" factor. This "educational bottom line," combined with a diminishing high school population, makes the Bureau of Labor Statistics' 2.6% projection for EE degree-growth understandable and calls for caution in thinking enrollment increases alone are going to provide an answer.

Increasingly educators voice concern as the extra students push resources beyond capacity. They warn that a decline in quality may result.

A 1980 University of New Orleans (UNO) study of 100 engineering schools provides insight into the enrollment-quality relationship (see Addendum C, Figure 1). 66% of the respondent schools felt enrollment was so high that it posed an immediate problem and handled it in a variety of ways.

* 45% (23 out of 51) increased the GPA requirements for transfer students

- 37% (21 out of 56) increased the GPA required of new students entering engineering
- 13% (6 out of 44) increased the prerequisite classes - upper or lower division
- 71% (28 out of 39) reported taking no steps to limit enrollment.

A Western Interstate Commission for Higher Education (WICHE) survey of 15 western engineering schools recently revealed that "most will have to limit enrollments within the next few years; a few of the larger universities are already operating under legislatively imposed university-wide enrollment ceilings."[17]

The present situation in engineering undergraduate education is characterized by plenty of students, but too few resources to educate them without risking a loss in quality.

## OUTDATED EQUIPMENT

John Fluke, President of John Fluke Manufacturing and a member of AEA's Blue Ribbon Committee, recently commented that on a visit to his alma mater he found some of the lab equipment he had trained on fifty years ago still in use.

According to an ASEE assessment, the engineering teaching equipment found in most university labs is 20-30 years old and equipment to teach new "growth technologies" is almost non-existent.[18] New technological processes, demanding sophisticated and costly equipment, have sky-rocketed the cost of teaching laboratories. Ohio State estimates installation of modern design equipment at $3 million plus 15% annual maintenance.

The Association of Independent Colleges estimated in 1978 that calculating 6.5 years as the useful life of instructional equipment, $1,500 per year per engineering baccalaurate degree would be needed to keep equipment up-to-date.[19] Applying this formula to last year's BS/EE graduates brings the annual price tag for electrical engineering teaching equipment alone to $20 million.

A distinction should be noted between research and teaching equipment money sources. Grants and contracts largely pay for research equipment.

Academic budgets and industry gifts are a primary source for instructional equipment. Few colleges can afford expensive CAD/CAM and integrated circuit technology teaching equipment and students will graduate without training in these important areas.

Industry requires modern equipment to compete in the marketplace with state-of-the-art technology. As a result, the "ivory research towers" are on industry land today and attract students who might formerly have chosen graduate study and even teaching careers.

## OUTDATED FACILITIES

Like equipment, most engineering labs and classrooms are now 30 years old. Federal money to build facilities has come in pennies over the last 20 years.[20] Inflation, OSHA regulations, and laws requiring building accommodations for the handicapped have compounded universities' inability to provide money for upgrade, repair, or expansion of their teaching plants.

## STATE ACTION

A few states are awakening to the resource shortage within their public postsecondary schools. They have begun funneling state funds into engineering education.

* University of Wyoming is spending $18 million on engineering facilities expansion.
* New Mexico recently funded a new engineering building at New Mexico State University and allocated $5 million a year for upgrading science and engineering at all state universities.
* At Arizona State University a five-year $32 million dollar program to establish an electronic and computer "center of excellence" by adding new facilities, equipment and a 63% faculty increase is in process.[21]
* The North Carolina General Assembly just allocated $24.4 million for the construction of a micro-electronics center. The North Carolina center will draw resources from five universities, a community college system, and the Research Triangle's private industries.[22]

- California budgeted $2.6 million to improve UC Berkeley's Cory Hall for micro-electronics instruction.

Nationally, however, much remains to be done. ASEE estimates it will take about $40 million per year to update lab equipment and modernize classrooms.[23]

## THE MOST CRITICAL PROBLEM - FACULTY SHORTAGES

Though too-little-too-old equipment and facilities are blocking an "increased throughput" of engineering students, the most serious current bottleneck is the faculty shortage.

Of the nation's some 20,000 engineering faculty jobs, 10% to 15% or 2,000 to 2,500 are presently unfilled. In fields such as solid-state electronics, computer engineering, and digital systems, NSF's Stephen Kahne places the shortage closer to 50%.[24]

Why are people turning away from teaching? Why, for instance, did only 8% (13 out of 160) of the new Stanford Ph.Ds choose teaching last year versus an estimate of 50% ten years ago?[25]

## THE DOCTORAL RECRUITMENT POOL

The student doctoral pool from which faculty traditionally comes is shrinking. Only very dedicated U.S. students and foreign students who know "they need higher degrees to compete with citizens for the same jobs"[26] go on to graduate study.

Foreign students are an increasing percentage of the EE doctoral pool. Of the 523 Ph.D/EE degrees awarded in 1980, 171 (33%) went to foreign students. Of these, 66% were on student visas and likely to return home.

### ENGINEERING Ph.Ds
### PERCENTAGE OF FOREIGN STUDENTS

1964 = 19.8%
1974 = 38.7%
1975 = 41.3%
1976 = 42.3%
1977 = 41.5%
1978 = 45.0%
1979 = 45.6%
1980 = 46.3%

Source: National Science Foundation

The majority of foreign students "are of very high caliber, among the best their country has, and graduate in the top fifth of their class."[27] Yet those who wish to remain in the U.S. face a six month to two year immigration process. Cultural and language differences pose an additional challenge for those who enter teaching.

## INDUSTRY-ACADEMIA SALARY INEQUITIES

Economics plays a significant role in faculty shortages.

BS graduates lack incentives to continue their education. Graduate assistant salaries average only $4,500 to $5,000 today. Rising tuition, housing and food costs, and the scarcity of fellowship monies (NSF's 1982 budget all but wipes them out) combine with the knowledge that "a young graduate can start at $5,000 more than his old teachers."[28] Few can resist industry's starting salaries of $20,000 to $24,000.

A 1980-81 ASEE Faculty Salary Survey shows the following average nine month salaries:

| | |
|---|---|
| Professors | $33,295 |
| Associate Professors | $25,793 |
| Assistant Professors | $21,758 |
| Instructors | $15,903 |

The UNO study (see Addendum C, Figure 2) reveals essentially the same salary pattern and further shows a relationship between salary and size of school.

Several years of doctoral study and five or more years of teaching must occur before academia's salaries become economically interesting--and then rarely more so than industry's.

## NON-FINANCIAL TEACHING INCENTIVES

Money has never been the sole reason people choose to teach. The opportunities to do research and promote growth of knowledge in students in a comparatively relaxed atmosphere have been strong attractions.

Research contracts have always been a prime faculty perquisite. NSF research contracts can provide up to 2/9ths of a salary supplement. For most other types of research contracts and grants, many universities allow up to one-third of the annual nine-month salary. Grants are becoming increasingly difficult to obtain.

As a percent of GNP, industrial R&D spending decreased from 2.1% in 1964 to 1.6% in 1979.[29] In spite of the investment downtrend, R&D spending at universities and colleges was up 3% in 1972-constant-dollars during 1979. Much of it, however, was not spent in idea generation or product development. It was spent meeting governmental and environmental regulations. Data from the center for the Study of American Business shows that the effect of increased government regulations on the cost-of-doing-business rose from $2,240 million in 1974 to $4,823 million in 1979.[30]

Teaching loads, commonly reduced to permit research, are becoming heavy. The University of New Orleans data (See Addendum C, Figure 2) shows the relationship between research and teaching loads. UNO respondents:

36% teach 9-to-11 hours a week
31% teach 12-to-14 hours a week

77% have reduced teaching loads to do research
    52% receive 1-to-3 hours reduction
    46% receive 4-to-6 hours reduction
22% responded that research was not a basis for a reduced load.

Academia's former "more relaxed atmosphere" has also been supercharged by high student-to-faculty ratios. For quality education, a ratio of 1 faculty to 20-25 students is considered ideal.[31] The UNO study show that only a few classes remain within the optimal range. (See Addendum C, Figure 3 In small schools of 500 or less students, the faculty-to-student ratio reaches as high as 1-to-118; 500 to 1,500 student schools as high as 1-to-51; 1,500 to 2,000 student institutions up to 1-to-48; and large schools of 2,000 or more 1-to-39.

Outdated and scarce facilities and equipment, insufficient R&D, increased teaching laods and high student-to-faculty ratios have diminished the non-financial incentives. A climate now exists where pay inequities make the final difference.

## SEVERITY OF FACULTY SHORTAGES

Almost 94% or 75 of the UNO respondents (see Addendum C, Figure 1) answered "Yes" to the question: "Are you experiencing difficulties in recruiting new, qualified faculty?" Engineering faculty is clearly a scarce commodity.

In June 1980 Dr. John Kemper, Dean of Engineering at UC Davis, surveyed 241 ABET-accredited engineering schools to quantify present and projected faculty shortages. He found 1,800 current faculty vacancies and 335 new openings due to retirement and 380 new vacancies for projected expansion per year. From 1981 to 1990, therefore, 7,525 new openings--an average of 750 per year--will be needed just for retirement and expansion.

Dr. Kemper adds 180 each year to "work off" current vacancies and finds the annual need for new engineering faculty to be 980 per year.[32]

## PROJECTED SHORTFALL OF FACULTY

Based on present trends, what is the projected annual shortfall of the teacher supply?

Approximately 2,700 Ph.Ds in engineering are awarded annually. Generally, 1,300 of these go to foreign students. 33% of these Ph.Ds have temporary resident status[33] and are likely, because of growing sensitivity to the American "brain drain," to return home.

The pool of U.S. students and foreign ones who remain after graduation comes to about 2/3 of the total degree recipients, or 1,800 people. Whereas in the 1960's 1-out-of-3 Ph.Ds went into teaching, today only 1 in 4 does.[34] Applying this 25% formula to the 1,800 suggests a supply of only 450 new faculty each year.

Dr. Daniel Drucker, Dean of College of Engineering at University of Illinois, Urbana-Champaign, says the supply is actually smaller, less than 300, since "quality instruction of undergraduates requires selection from among the upper third (or higher) of all Ph.Ds."[35] Whether 300 or 450 are available, the shortfall to the needed 1,000 is still large.

Assuming that 2/3 of the total Ph.D engineering graduates continue to enter U.S. employment and that they return to the 1-out-of-3-who-choose-to-teach formula, we will need to increase the supply of doctoral-level engineers by 1,300 each year (to a total of 4,000 doctoral graduates) to receive the needed 1,000 faculty.

## IV

## EFFECT OF CONTINUED SHORTAGES

### ECONOMIC, POLITICAL, AND SOCIAL IMPACT

The United States is still the most productive country in the world. Yet while others improve their ratio of output-per-worker, America does not--dropping from a WWII 2.9% increase to a minus 0.9% in 1979.

Japan's productivity makes U.S. industries jog faster to run the economic mile. On a per capita basis, Japan has fewer than 1/20th the lawyers, 1/7th the accountants, but 5 times as many engineers as the United States.[36]

The Soviet Union's double time to reach "scientific and technological supremacy"--graduating 6 times as many undergraduate engineers as the U.S.[37]--causes discomfort in America's national defense arenas.

According to a 1977 NSF study, high technology has twice the productivity, triple the real growth, six times fewer price increases, and nine times more employment when compared to low technology industries.[38] Electronics in particular holds the promise of winning on the economic, political, and social fronts--if the engineer shortages are reversed.

> "The lack of electronic and computer science engineers may be the single most important factor limiting the growth and continued vitality of electronics industries."
>
> Dr. William Perry, Partner, Hambrecht & Quist
> Former U.S. Undersecretary of Defense for
> Research and Engineering

## V

## VIEWS ON THE SHORTAGE

A variety of views on the shortages of engineers has been expressed in professional associations and trade journals. A consensus is forming. Stephen Kahne, Director of the Division of Electrical, Computer, and Systems Engineering at the National Science Foundation (NSF) puts the matter into perspective:

> It is no longer an open question whether the shortage of electrical engineers in the United States is or is not a crisis. It is. Sooner or later every U.S. industry dependent upon electrical engineering will be affected--and there are more such industries now than ever. Toy and automobile manufacturers, even textile and clothing companies, have discovered the value of electronics and computer-based systems in their products or manufacturing processes. Indeed, these new industries, previously unaffected by electrical engineering in any significant way, are the hidden factor that invalidates traditional market surveys of future needs for EEs. It is hard to predict the growing need for electronics specialists in sectors of the economy that never before employed them.[39]

## REFERENCES

[1] Ray Stata, President and Chairman, Analog Devices, Inc., "Needed: A Plan for Educating Engineers." *Electronics*, April 24, 1980, p. 26.

[2] "The Electronic Business 100." *Electronic Business*, February 1981, p. 64.

[3] Robert G. Gillespie, Vice Provost for Computing with Deborah A. Dicaro, Research Associate, University of Washington. *Computing and Higher Education: an Accidental Revolution*, 1981, p. 5.

[4] Electronics industries' annual percentage of promotion of exempt employees into management established by survey of AEA Industrial Relations Committee, 1980.

[5] Estimated by National Science Foundation and American Society for Engineering Education.

[6] Quote by Walter V. Nichols, Vice President of Fox-Morris Personnel Consultants, San Francisco. *Electronic Design*, September 1980.

[7] "Briefs: Information Processing." *Business Week*, August 3, 1981, p. 68F.

[8] *Scientific, Engineering, and Technical Manpower Comments*, Washington, D.C., June 1981, p. 5.

[9] *Wall Street Journal*, July 14, 1981, p. 1.

[10] John Radick, "Firms Vying for Scarce Engineering Talent," *Electronic News*, June 15, 1981, p. 40.

[11] Gerald F. Seib and Roy J. Harris, Jr., "Defense Tactics: In Military Buildup, Big Contractors Face Supplier Bottlenecks; Where Are the Engineers?" *Wall Street Journal*, August 21, 1981, p. 11.

[12] *Technical Employment Projections Survey: 1981-83-85. American Electronics Association, Palo Alto, California, June 1981, p. 76.*

[13] J. D. Kemper, Dean of Engineering, UC Davis, "Graduate Enrollments in Engineering; Meeting National Needs for Productivity," July 1980, p. 9. Source reference: *Quarterly Unemployment Rates for Engineers Released*, Engineering Manpower Highlights, Pub.No. 225, Engineers Joint Council, New York, November 1972.

[14] Stephen Kahne, NSF Presentation, May 7, 1981. Slide No. ECS 81-1756, 4-1-81.

[15] *The International Microelectronic Challenge*. The Semiconductor Industry Association, Cupertino, California, May 1981, p. 29.

[16] Roger Lowenstein, "Two-Edged Sword: Surge in Engineering Enrollment Begins to Ease Industry's Shortages but Stirs Trouble at Colleges." *Wall Street Journal*, August 20, 1981, p. 48.

[17] "Can Higher Education Meet the Need for Technical Manpower?" *WICHE Reports*. Summer, 1981, p. 11.

[18] Ward Worthy, "Chemical Education Falls on Hard Times." *C & EN*, February 9, 1981, p. 45.

[19] Task Force Chaired by Robert H. Page, Texas A&M University, "Data Related to the Crisis in Engineering Education." March 1981, AAES, ASME, ASEE, p. 11.

[20] *Issues in Engineering Education, a Framework for Analysis*, Task Force on Engineering Education of the National Academy of Engineering. Washington, D.C., April 1980, p. 13.

[21] *WICHE*, p. 12.

[22] "Micro Center Gets $24.4 Million From Legislature." *Future State*, Mark Ernsberger, ed., First Union National Bank, Charlotte, North Carolina, August 1981.

[23] Worthy. *C & EN*, p. 45.

[24] Stephen Kahne, National Science Foundation, "A Crisis in Electrical Engineering Manpower." *IEEE Spectrum*, June 1981, p. 50.

[25] Summary, Meeting of the Engineering Manpower Task Force, Business-Higher Education Forum, St. Louis, Missouri, April 7, 1981, p. 3. American Council on Education, Washington, D.C.

[26] "Wanted: U.S.-born Graduate Students." *Chemical Week*, June 24, 1981, p. 45.

[27] *Ibid.*, p. 46.

[28] Trends: "The Vanishing Professor." Forbes, July 20, 1981, p. 8.

[29] "The Problem: The Decline in U.S. Productivity." Business Week, June 30, 1980, p. 60.

[30] Kahne, Slide Presentation, 4-1-81. ECSE81-1049, 12-18-80.

[31] Wm. S. Janna, University of New Orleans, "The Enrollment Crunch: A National Survey." Engineering Education, April 1981, p. 706.

[32] Kemper, "Graduate Enrollments In Engineering," p. 8.

[33] NSF and NRC, Summary Report, "Doctorate Recipients from U.S. Universities." 1979.

[34] "National Crisis: A Severe Engineering Faculty Shortage," Shakertown Conference, December 3 and 4, 1980, Pleasant Hill, Kentucky. Shakertown at Pleasant Hill, Kentucky, Inc., Harrodsburg, Kentucky, 40330, p. 1.

[35] Daniel C. Drucker, Dean, College of Engineering, University of Illinois at Urbana-Champaign, Statement before Subcommittee on Science Research and Technology of the Committee on Science and Technology, U.S. House of Representatives, March 3, 1981, p. 5.

[36] Claudia Deutsch. Business Week, July 6, 1981, p. 105.

[37] Catherine P. Ailes and Frances W. Rushing, "A Summary Report on the Educational Systems of the U.S. and the Soviet Union: Comparative Analysis." Prepared for NSF, SRI International, Final Report, March 1980, p. iii.

[38] "Revitalizing the U.S. Economy." Business Week, June 30, 1980, p. 103.

[39] Kahne. IEEE Spectrum, p. 50.

# ADDENDUM A

**Summary of enrollment in educational institutions[1], with projections, by level of institution: Fall 1970 to fall 1988**

| Fall of year | Total enrollment | Elementary schools (Grades K–8) | High schools (Grades 9–12) | Institutions of higher education |
|---|---|---|---|---|
| | | (In thousands) | | |
| 1970 | 59,899 | 36,686 | 14,632 | 8,581 |
| 1971 | 60,152 | 36,088 | 15,116 | 8,948 |
| 1972 | 60,000 | 35,569 | 15,216 | 9,215 |
| 1973 | 59,982 | 34,999 | 15,380 | 9,603 |
| 1974 | 60,340 | 34,584 | 15,532 | 10,224 |
| 1975 | 61,063 | 34,174 | 15,704 | 11,185 |
| 1976 | 60,507 | 33,768 | 15,727 | 11,012 |
| 1977 | 59,955 | 32,951 | 15,720 | 11,284 |
| 1978 | 58,948 | 32,061 | 15,628 | 11,259 |
| | | Projection | | |
| 1979 | 58,129 | 31,376 | 15,245 | 11,508 |
| 1980 | 57,382 | 30,974 | 14,797 | 11,611 |
| 1981 | 56,602 | 30,614 | 14,298 | 11,690 |
| 1982 | 55,695 | 30,217 | 13,808 | 11,670 |
| 1983 | 55,381 | 30,273 | 13,495 | 11,613 |
| 1984 | 55,122 | 30,208 | 13,422 | 11,492 |
| 1985 | 55,111 | 30,257 | 13,496 | 11,358 |
| 1986 | 55,292 | 30,675 | 13,402 | 11,215 |
| 1987 | 55,576 | 31,369 | 13,103 | 11,104 |
| 1988 | 55,938 | 32,223 | 12,667 | 11,048 |

[1] Includes public and private institutions.

NOTE: Details may not add to totals because of rounding.

SOURCE: U.S. Department of Health, Education and Welfare, National Center for Education Statistics, *Projections of Education Statistics to 1988–89*, 1980.

## ADDENDUM B

Figure 1

Source: National Opinion
Research Center

Reported in Manpower Comments, May, 1981, p. 26.

FIELD OF COLLEGE STUDY PLANNED BY HIGH SCHOOL SENIORS

| | 1980 | 1972 |
|---|---|---|
| Business | 22% | 13% |
| Engineering | 10% | 5% |
| Health services | 8% | 12% |
| Preprofessional | 8% | — |
| Education | 6% | 12% |
| Computer and information science | 5% | 2% |
| Social sciences | 8% | 17% |
| Art | 4% | 3% |
| Communications | 4% | 2% |
| Vocational or technical | 3% | 3% |
| Biological sciences | 3% | 10% |
| Agriculture | 2% | 3% |
| Architecture | 2% | 2% |
| English | 2% | 3% |
| Home economics | 2% | 2% |
| Music | 2% | 3% |
| Physical science | 2% | 3% |
| Foreign language | 1% | 1% |
| Mathematics | 1% | 2% |
| Philosophy or religion | 1% | 1% |
| Other fields | 4% | 0.5% |

Figure 2 U.S. ENGINEERING GRADUATES

ELECTRICAL ENGRS

| | NUMBER OF DEGREES | | | | ANNUAL % GROWTH | | | |
|---|---|---|---|---|---|---|---|---|
| YEAR | B.S. | M.S. | PH.D. | TOTAL | B.S. | M.S. | PH.D. | TOTAL |
| 1970 | 11921 | 4150 | 873 | 16944 | 4.80 | 2.49 | 1.75 | 4.07 |
| 1971 | 12145 | 4359 | 899 | 17403 | 1.88 | 5.04 | 2.98 | 2.71 |
| 1972 | 12430 | 4352 | 850 | 17632 | 2.35 | -0.16 | -5.45 | 1.32 |
| 1973 | 11844 | 4151 | 820 | 16815 | -4.71 | -4.62 | -3.53 | -4.63 |
| 1974 | 11347 | 3702 | 700 | 15749 | -4.20 | -10.82 | -14.63 | -6.34 |
| 1975 | 10277 | 3587 | 673 | 14537 | -9.43 | -3.11 | -3.86 | -7.70 |
| 1976 | 9954 | 3782 | 644 | 14380 | -3.14 | 5.44 | -4.31 | -1.08 |
| 1977 | 9837 | 3674 | 574 | 14085 | -1.18 | -2.86 | -10.87 | -2.05 |
| 1978 | 10702 | 3475 | 524 | 14701 | 8.79 | -5.42 | -8.71 | 4.37 |
| 1979 | 12213 | 3335 | 545 | 16093 | 14.12 | -4.03 | 4.01 | 9.47 |
| 1980 | 13745* | 3740* | 523 | 18008* | 12.54 | 12.14 | -4.04 | 11.90 |

*Errata sheet from Engineering Manpower Commission corrects 1980 BS/EE degrees to 13,594, MS/EE to 3,660, total all degrees to 17,777.

COMPUTER ENGRS

| | NUMBER OF DEGREES | | | | ANNUAL % GROWTH | | | |
|---|---|---|---|---|---|---|---|---|
| YEAR | B.S. | M.S. | PH.D. | TOTAL | B.S. | M.S. | PH.D. | TOTAL |
| 1970 | 139 | 185 | 34 | 358 | 167.31 | 54.17 | 54.55 | 84.54 |
| 1971 | 174 | 250 | 44 | 468 | 25.18 | 35.14 | 29.41 | 30.73 |
| 1972 | 359 | 627 | 83 | 1069 | 106.32 | 150.80 | 88.64 | 128.42 |
| 1973 | 568 | 589 | 96 | 1253 | 58.22 | -6.06 | 15.66 | 17.21 |
| 1974 | 727 | 723 | 83 | 1533 | 27.99 | 22.75 | -13.54 | 22.35 |
| 1975 | 599 | 678 | 107 | 1384 | -17.61 | -6.22 | 28.92 | -9.72 |
| 1976 | 796 | 718 | 90 | 1604 | 32.89 | 5.90 | -15.89 | 15.90 |
| 1977 | 1280 | 802 | 136 | 2218 | 60.80 | 11.70 | 51.11 | 38.28 |
| 1978 | 1546 | 986 | 123 | 2655 | 20.78 | 22.94 | -9.56 | 19.70 |
| 1979 | 1510 | 1074 | 190 | 2774 | -2.33 | 8.92 | 54.47 | 4.48 |
| 1980 | 1816 | 1262 | 159 | 3237 | 20.26 | 17.50 | -16.32 | 16.69 |

SOURCE: ENGINEERING MANPOWER COMMISSION

*The Rosen Electronics Letter, December 31, 1980*

# ADDENDUM C

Figure 1

Engineering College Limits on Enrollment and Class Size, 1980.

| College Enrollment Range | Enrollment increases 0-5% | 6-10% | 11-15% | 16-20% | 21-25% | over 25% | | Enrollment Limitation—C A | B | a | b | c | d | D | E | Average Class Size Limit Type of Course | < 15 | 15-20 | 21-25 | 26-30 | 31-35 | 36-40 | 41-45 | 46-50 | over 51 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| < 500 | 3 | 9 | 2 | 1 | 2 | 1 | Y | 13 | 12 | 2 | 1 | 1 | 14 | 16 | 18 | Service | | 1 | 2 | 8 | 2 | 2 | | 3 | 3 |
| | | | | | | | N | 8 | 7 | 7 | 10 | 8 | 2 | 5 | 3 | Non | | 1 | 8 | 2 | 2 | 4 | 1 | 2 | |
| 500-1500 | 3 | 9 | 6 | | 3 | 3 | Y | 18 | 15 | 8 | 9 | 2 | 6 | 15 | 22 | Service | | | | 8 | 5 | 3 | | 3 | 8 |
| | | | | | | | N | 8 | 11 | 10 | 10 | 14 | 5 | 11 | 1 | Non | | 2 | 4 | 5 | 1 | 2 | | 2 | 5 |
| 1500-2000 | 3 | 6 | 6 | 4 | 1 | | Y | 11 | 15 | 7 | 5 | 3 | 4 | 15 | 21 | Service | | | 1 | 2 | 5 | 1 | 2 | 3 | 6 |
| | | | | | | | N | 5 | 5 | 7 | 11 | 9 | 4 | 7 | 1 | Non | | | 3 | 7 | 2 | 2 | 1 | 4 | 3 |
| > 2000 | 1 | 7 | 2 | 1 | | | Y | 7 | 9 | 8 | 6 | 0 | 4 | 3 | 14 | Service | | | | 2 | 2 | 1 | 1 | 2 | |
| | | | | | | | N | 6 | 3 | 4 | 4 | 7 | 0 | 7 | 0 | Non | | | 1 | 1 | 4 | 1 | | 2 | 2 |

A—Is this (the enrollment increases in the college) unusually high?
B—If appropriate, has the enrollment increase presented a problem which needed immediate attention?
C—Several questions on whether or not steps were taken to limit enrollment
a) Increasing the GPA requirement of transfer students
b) Increasing the GPA requirement of students entering engineering
c) Raising the prerequisites of lower and/or upper level courses
d) No steps were taken to limit enrollment
D—As necessary, have new engineering positions been provided at your institution to maintain a "manageable" student/faculty ratio?
E—Are you experiencing difficulties in recruiting new "qualified faculty"?

Figure 2

Engineering Faculty Salaries, 1980.

| College Enrollment Range | Average Teaching Load 3-5 hrs | 6-8 hrs | 9-11 hrs | 12-14 hrs | over 15 hrs | A | | B 1-3 hrs | 4-6 hrs | over 6 hrs | Salary of Graduate Assistant 9-Month Contract 3.0-3.5 K | 3.5-4.0 K | 4.0-4.5 K | 4.5-5.0 K | 5.0-5.5 K | 5.5-6.0 K | 6.5-7.0 K | over $7,000 | Salary of Assist Prof 9-Month Contract 16-17 K | 17-18 K | 18-19 K | 19-20 K | 20-21 K | 21-22 K | over 22 K | Salary of Assoc Prof 9-Month Contract 22-23 K | 23-24 K | 24-25 K | 25-26 K | 26-27 K | over 27 K |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| < 500 | 1 | 2 | 11 | 8 | | Y | 9 | 7 | 4 | | 2 | 7 | 1 | | 1 | | 1 | 1 | 1 | 6 | 3 | 6 | 3 | 2 | 3 | 6 | 7 | 2 | 2 | 2 | 1 |
| | | | | | | N | 7 | | | | | | | | | | | | | | | | | | | | | | | | |
| 500-1500 | 1 | 6 | 9 | 10 | | Y | 21 | 12 | 6 | | 3 | 7 | 3 | 3 | | 2 | | | 1 | 3 | 7 | 2 | 5 | 6 | 3 | 4 | 9 | 4 | 2 | 2 | 3 |
| | | | | | | N | 5 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1500-2000 | | 12 | 5 | 5 | | Y | 17 | 4 | 9 | 1 | 2 | 4 | 10 | 2 | | 1 | 1 | 1 | | 3 | 2 | 4 | 4 | 10 | 1 | 3 | 5 | 5 | 3 | 4 | 2 |
| | | | | | | N | 2 | | | | | | | | | | | | | | | | | | | | | | | | |
| > 2000 | 1 | 4 | 6 | 3 | | Y | 9 | 3 | 4 | | 1 | 2 | 1 | 3 | 4 | | 1 | 2 | 1 | 1 | 3 | 2 | 2 | 3 | 1 | 3 | 1 | 1 | 5 | | |
| | | | | | | N | 2 | | | | | | | | | | | | | | | | | | | | | | | | |

A—Is research a basis for reduction in teaching load?
B—If so, how much of a reduction?
Note: Assistant and associate professor salaries are average starting salaries for an individual starting work in fall 1980.

Figure 3

Departments of Electrical Engineering, 1980.

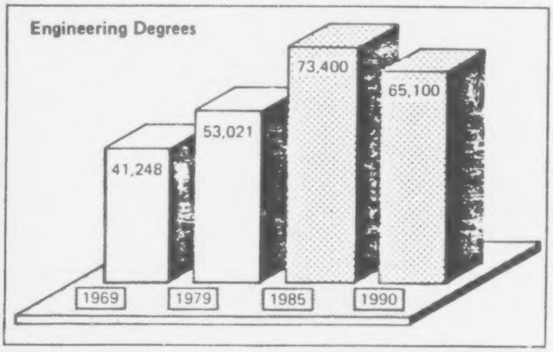
| College Enrollment Range | | Student/ Faculty Ratio | No. of Faculty | Enrollment Increases 0-5% | 6-10% | 11-15% | 16-20% | 21-25% | over 25% |
|---|---|---|---|---|---|---|---|---|---|
| < 500 | Hi | 116 | 30 | 2 | 5 | 4 | 2 | 1 | 2 |
| | Lo | 8 | 4 | | | | | | |
| | Av | 25.2 | 10.6 | | | | | | |
| 500-1500 | Hi | 51.5 | 19 | 5 | 3 | 5 | 2 | 2 | |
| | Lo | 11 | 4 | | | | | | |
| | Av | 23.2 | 10.4 | | | | | | |
| 1500-2000 | Hi | 48.4 | 38 | 2 | 8 | 1 | 6 | | 4 |
| | Lo | 5 | 9 | | | | | | |
| | Av | 20.1 | 20.7 | | | | | | |
| > 2000 | Hi | 39.9 | 100 | 1 | 6 | 2 | | | 2 |
| | Lo | 13.7 | 4 | | | | | | |
| | Av | 24.0 | 44.5 | | | | | | |

SOURCE: William S. Janna, University of New Orleans, "The Enrollment Crunch: A National Survey." Engineering Education, April 1981, pp. 706-707.

ADDENDUM D

## "EFFECTS OF DEMOGRAPHICS ON ENGINEERING ENROLLMENTS"

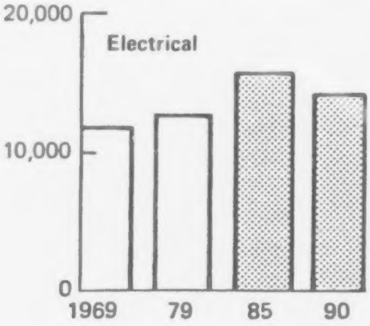
**Chart 1–Total Bachelor's degrees in engineering**



The projected increase in engineering degrees to 1985 reflects dramatic increases in engineering enrollments as documented by NCES[2] and the Engineering Manpower Commission.[3] The decline in 1990 reflects demographic changes – decreases in the college-age population – which are expected to impact at that time. The decline should result in degree outcomes that are lower than the 1985 projections for total engineering.

Source: National Center for
Education Statistics
February 13, 1981

Bulletin NCES 81-406



# ADDENDUM E

## AEA BLUE RIBBON COMMITTEE ON ENGINEERING EDUCATION

Committee Chairman
Dr. William J. Perry, Partner
Hambrecht and Quist

Dr. Richard Atkinson, Chancellor
University of California, San Diego

Dr. Joseph A. Boyd, Chairman of the Board and Chief Executive Officer
Harris Corporation

John M. Fluke, Chairman
John Fluke Manufacturing Company, Inc.

Dr. C. Lester Hogan, Director and Consultant
Fairchild Camera and Instrument Corporation

Dr. Robert N. Noyce, Vice Chairman
Intel Corporation

Dr. Joseph Pettit, President
Georgia Institute of Technology

Dr. Allen E. Puckett, Chairman
Hughes Aircraft

Ray Stata, Chairman and President
Analog Devices, Inc.

Dr. Dean A. Watkins, Chairman
Watkins-Johnson Company

Dr. Karl Willenbrock, Green Professor of Engineering
Southern Methodist University

John A. Young, President and Chief Executive Officer
Hewlett-Packard Company

# ADDENDUM F

## TOP 10 STATES AWARDING EE/CS DEGREES
## 1979 - 1980

| State | Bachelor's | Master's | Doctor's | TOTAL |
|---|---|---|---|---|
| 1. California | 1,626 | 1,123 | 160 | 2,909 |
| 2. New York | 1,621 | 609 | 73 | 2,303 |
| 3. Massachusetts | 881 | 307 | 49 | 1,237 |
| 4. Pennsylvania | 887 | 198 | 34 | 1,119 |
| 5. Illinois | 750 | 289 | 64 | 1,103 |
| 6. Michigan | 843 | 197 | 15 | 1,055 |
| 7. Texas | 680 | 274 | 37 | 991 |
| 8. Ohio | 640 | 279 | 33 | 952 |
| 9. Indiana | 488 | 101 | 29 | 618 |
| 10. Missouri | 507 | 82 | 21 | 610 |
| | | | | |
| Top 10 Total | 8,923 | 3,459 | 515 | 12,897 |
| U.S. Total | 15,410 | 4,914 | 682 | 21,006 |
| Top 10 Share of Total | 58% | 70% | 76% | 61% |

## SCHOOLS AWARDING THE MOST ENGINEERING DEGREES
## 1979 - 1980

from Engineering
Manpower Commission, 1980

### ALL ENGINEERING DEGREES COMBINED

| Bachelor's | | Master's | | Doctor's | |
|---|---|---|---|---|---|
| Purdue | 1442 | Stanford | 770 | MIT | 162 |
| U Illinois (Urbana) | 1257 | MIT | 673 | U Illinois (Urbana) | 156 |
| Penn State | 1136 | Cal Berkeley | 571 | Cal Berkeley | 131 |
| Texas A & M | 1081 | Poly Inst. NY | 512 | Stanford | 110 |
| Georgia Tech | 985 | U Michigan(Ann Arbor) | 415 | Purdue | 91 |
| U Michigan (Ann Arbor) | 917 | U Illinois (Urbana) | 406 | Cornell | 82 |
| U Missouri (Columbia) | 794 | USC | 397 | Ohio State | 63 |
| U Missouri (Rolla) | 768 | Geo. Washington U | 317 | USC | 62 |
| U Washington | 766 | Purdue | 295 | UCLA | 58 |
| Virginia Tech | 762 | Georgia Tech | 294 | Northwestern | 53 |

### EE DEGREES

| | | | | | |
|---|---|---|---|---|---|
| U Illinois | 293 | Stanford | 216 | MIT | 48 |
| Purdue | 275 | USC | 158 | Stanford | 33 |
| MIT | 270 | MIT | 151 | USC | 32 |
| U Missouri (Col.) | 254 | Georgia Tech | 109 | U Illinois | 32 |
| Georgia Tech | 237 | Purdue | 96 | Purdue | 25 |
| U Washington | 204 | Poly Inst NY | 91 | UC Santa Barbara | 21 |
| Penn State | 199 | U Illinois | 90 | Cornell | 15 |
| U Minnesota | 188 | Rensselaer Poly | 80 | U Texas | 11 |
| U Texas | 176 | Ohio State | 71 | Ohio State | 10 |
| Virginia PI | 171 | Cornell | 68 | U Mo. (Columbia) | 9 |
| | | | | U Syracuse | 9 |

### CS DEGREES

| | | | | | |
|---|---|---|---|---|---|
| Cal Berkeley | 256 | Cal Berkeley | 147 | Cal Berkeley | 31 |
| U Illinois | 118 | Poly Inst NY | 94 | MIT | 17 |
| Oregon State | 106 | Northwestern | 70 | U Illincis | 15 |
| Texas A & M | 87 | U Michigan | 61 | Purdue | 12 |
| U Michigan | 78 | USC | 56 | Northwestern | 12 |
| Michigan State | 73 | U Pennsylvania | 51 | UCLA | 11 |
| UC San Diego | 61 | Ohio State | 45 | Princeton | 11 |
| Connecticut U | 58 | UCLA | 44 | Ohio State | 10 |
| Rensselaer Poly | 52 | U Illinois | 41 | U Washington (Mo.) | 7 |
| U Illinois | 49 | S. Clara U | 40 | Cornell | 7 |
| CC New York | 49 | U Oklahoma | 40 | | |

Senator **Bentsen**. Mr. Weinig, we're very pleased to have you here this morning. I look forward to hearing your testimony.

## STATEMENT OF SHELDON WEINIG, PRESIDENT AND CHIEF EXECUTIVE OFFICER, MATERIALS RESEARCH CORP., ORANGEBURG, N.Y.

Mr. **Weinig**. Thank you, Senator, I have a prepared statement for the record, and with your permission, I will try to summarize it in the interest of brevity.

I would like to, of course, thank the subcommittee and the Joint Economic Committee for inviting me to appear here today to testify on the Nation's skilled labor shortage. I'm testifying on behalf of my firm, Materials Research Corp. of Orangeburg, N.Y., and the American Business Conference, which is a coalition of high growth, midrange companies.

I am the president and chief executive officer of Materials Research, a company I founded in 1957 after a brief, successful, and unprofitable career as a professor. [Laughter.]

My company's business, interestingly enough, is to supply the needs of Professor Willenbrock's organization, AEA. We are suppliers to the electronics industry throughout the world and manufacture in Europe, the United States, and Japan. Our customers are their members, so I thoroughly understand and am sympathetic with the problems of that industry.

Senator **Bentsen**. Well, Mr. Willenbrock may be profiting from you, and I had a closer shave this morning, thanks to you, as well.

Mr. **Weinig**. That's true, sir. The thin film that's used in the integrated circuit, which is the industry that we are in, is also the Platinum Plus that you have used and something I invented about 12 years ago. I'm sorry to admit that it really doesn't make the blade sharper; it just keeps it dull forever. [Laughter.]

Senator **Bentsen**. At least I thought I felt better. [Laughter.]

Mr. **Weinig**. Your decision to focus on the Nation's skilled labor shortage is extraordinarily timely. I certainly hope it generates greater public awareness and that some support is forthcoming from these hearings, because the challenge is equal to if not greater than the capital formation one.

Now I am going to move through some of these areas that Mr. Willenbrock has touched on, but I would like to make very clear my own feelings about this very peculiar problem of having an insufficient number of U.S. citizens involved in high technology education and in the actual teaching.

Just to add some more fuel to the fire, I believe you did say that about 50 percent of all of the graduate students in the technical schools of the United States are foreign, and a real eye-opener, if I understood you, in a number of colleges, about 80 percent of all new faculty are foreign. That's an astounding number. Across the board, I guess it's about one-third of all junior faculty in the United States, engineering schools, have their first degree from a foreign university.

Now I'm not going to get deeply into this because this has already been covered, but frankly I would urge this committee to give very serious consideration to this particular aspect. Again to repeat what was said, it is not a problem of too many foreign students; it's just a problem of too few U.S. citizens who want to become involved in this particular route of engineering science and academia thereafter.

I would like to now move on and discuss the actual engineering aspect of the program. I will not get involved in the age-old question of, do we have too many engineers or too few engineers doing engineering? The real problem is very simply that engineering is a profession that produces people, and upon graduation, the first thing they do is try to get out of engineering. I'm not really sure I thoroughly understand that, but there are some reasons that we can discuss later, if you will, sir.

More engineers go into business schools than any other undergraduate curriculum in the United States. The numbers are astounding.

It's interesting because one would consider the combination of an engineering degree and an MBA would make a very potent human being. The truth of the matter, sir, is it doesn't. It makes what I sometimes call a misfit, and after two drinks. I call a gelding, because there's very little creativity left after those two degrees. [Laughter.]

The combination just hasn't worked, and yet it hasn't stopped the sheer number of engineering students studying for their MBA's.

Another aspect of this lack of hands-on engineering can be understood from the following data. Japan, which is our major competition in the electronics area as well as others, produces about 20,000 bachelor's degrees in electrical engineering per year. Ten percent of them go on to graduate school. But what nobody discusses is that a large portion of that 10 percent goes to graduate school in the United States.

In the United States, we produce about 12,500 electrical engineers per year and about a third of them go to graduate schools. So again we see this phenomenon of not getting working engineers. We're not getting the engineer who wants to put his hands directly on the project and therein lies a serious part of this problem.

Perhaps the most compelling treatise is in a recent book by Tracy Kidder called "The Soul of a New Machine." In this book, they describe a group of 30 to 40 engineers who devote 18 months of their life to the development of a new computer. They do this 7 days a week, multiple shifts. They sacrifice family and health. At the end of 18 months, they produce this fantastic new computer. The sad and bottom line, sir, is that the payoff is literally zero, that is, they get neither monetary or other recompense for their great effort.

In other words, ladies and gentlemen, if I may put it in very bold type, real engineering does not pay in our society. Nor is it highly recognized in our society. And I think therein lies a serious problem, because you're not going to attract super-bright kids into a profession that doesn't have a payoff.

There are some who ridicule being an engineer. One girl says to another, "If he's wearing brown shoes, white socks, and a blue suit, he's probably an engineer." Well, what they're really doing is rejecting the recognition of this particular profession. Therein lies part of the problem. You've got to make it attractive: then people will go into it.

Well, now to my main thesis——

Senator **Bentsen**. Well, also part of the profile is that engineers do not have a sense of humor. You obviously are refuting that.

Mr. **Weinig**. Sir, after 20 years in business, I no longer consider myself an engineer. I use the doctorate title to get me into places, they all think I'm an obstetrician. [Laughter.]

My main thesis today has to deal with the area of technical paraprofessionals. This is one of great personal and, I think, countrywide concern.

In August 1981, the U.S. Department of Labor published a report in which they attempted to predict those areas in which we would have personnel shortages by 1990 against a base of 1978. They have various economic scenarios, but let's take the most conservative scenario. The six areas of greatest shortage are data processing, machine mechanics, paralegal personnel, computer systems analysts, computer operators, office machine and cash register maintainers or servicers, and computer programers.

In other words, of the first six categories, five are directly computer related. These are all paraprofessional jobs. It is this type of person—and you can add to that technicians, drafters, and assemblers of complex machines—these are the people that are in short supply and constitute our skilled labor shortage, and I would like to discuss this area.

It is interesting that most of them are a derivation of what I call the fourth computer revolution. The first, you will recall, was the main frame; then we had the miniframe; then we had the microprocessor or computer on a chip. Well, the fourth computer revolution is the terminal revolution, and I certainly hope that's not prophetic. But the reality here is that the terminal within the 20th century within our lifetime is going to be total; it's going to be in our homes, our cars, offices, on the factory floor. The terminal is going to be the site of instruction, of information exchange; it's going to be the totality of our communication with the world.

The first thing one notes is that half of the people in industry, including trained engineers, are completely scared to death of this phenomenon. Perhaps they're afraid of interfacing with the terminal; maybe they're afraid of using it, or maybe they're afraid of being used by it.

If you've been involved in any form of conversion in industry where terminals are put on line whether for order processing or inventory, whatever, there's tremendous trepidation manifested by the people. I suspect the answer to this problem will probably occur in the home when each homekeeper will have a terminal which they will use to buy, pay their bills, and maybe even reconcile their bank accounts. For some reason or other, new technology is more acceptable in the home than it is in the factory. Perhaps it is less threatening.

Nevertheless, the problem is, are we producing technical paraprofessionals? Well, we really are not, certainly not in the numbers that are required.

What do we do in a company like our own? Let's take MRC. My company has a no-layoff policy. That means, I've never layed off anyone for lack of work. So it means on occasion I have to move people and they have to learn new job skills. This becomes a little disconcerting for them and you might expect that perhaps they would therefore pursue some greater training to become a technical paraprofessional, and that's easy because we also have a 100 percent educational reimbursement program. You can literally take anything but cooking and dancing. But the reality is, very few people take advantage of it. The only people who pursue these programs are those seeking baccalaureates or graduate work for some of my engineering staff. We don't produce the paraprofessional.

Finally, we have a New York State job incentive program, but this is fundamentally an apprentice program. I must make a very critical point about paraprofessional training. And that is, sir, that an apprentice style program will not train and develop the paraprofessional.

The paraprofessional must be trained by full-time trainers. There is significant equipment required, and there is significant time. Despite a number of company programs and local government programs we really have nothing directed at this specific area of training skilled paraprofessionals.

Therefore, what are we to do about this critical shortage of paraprofessionals? These are special skills. I repeat, they will not be learned on the job. They must be trained. And the problem fundamentally begins in the high school.

We have high schools, sir, that are totally college oriented. Any kid that is not college oriented is put into other schools that we used to call trade schools. They've become nothing more than holding pens in many instances, to hold the young people for the requisite number of years until they can be turned free.

Our first job is to identify, inspire and train these young people. We want the people who are ready to learn, because the teaching of technological skills requires a commitment on the part of the student and a willingness to adapt to the workplace.

And so I am recommending today a combination——

Senator **Bentsen**. Let me interrupt at that point. When you talk about these holding pens, how effective has been the matching up of job availabilities and the growth in areas where you're going to have the jobs with what is actually being taught in some of these vocational schools?

Mr. **Weinig**. Well, the problem, sir, is that there are very few high school student that enter these vocational programs in areas that are contiguous to where the jobs are.

Senator **Bentsen**. How good a job is being done in our high school vocational programs?

Mr. **Weinig**. It's inadequate, sir. In my area, which is Rockland County, N.Y., 15 miles north of the city, there is an industrial BOCES, type of organization; they turn out between six and eight students while IBM, who is in the general area, could use 300, and we could probably use 50 to 100. So it just isn't happening. The contiguousness of the job and the training is not there, and the young people are just not getting into these industrial training programs. They are not inspired to go into them.

We have a problem in this country in that the high school student that is not college oriented comes out without a skill. But more importantly he comes out without any expectation. He just comes out—it's as sad as that—he just comes out; he has no expectation, and he has no skill. And that's the problem we really have to address. I hope perhaps with the program I would like to describe, that there may be some seed of help here.

Senator **Bentsen**. All right.

Mr. **Weinig**. What I should like to recommend is a combination program which is aimed essentially at the mid-range growth companies. The real fact is that these companies are the ones that have been growing over the last 10 years, and these are the companies that will continue to grow. It is not superbig America that has been growing in the last few years.

This program will provide training tax incentives to the companies for only training people in special skills leading to careers in technical-paraprofessional types of positions. These are not job incentives. The jobs exist, sir. What doesn't exist is the training.

The program may function on-site at the company, or it could be in cooperation with other companies in which they might utilize the bricks and mortar that is either government-owned or school-owned but is available. These centers can be located near the potential candidates. They can be moved closer to where the source of the students might be or the potential jobholders.

As the people are trained, it's even conceivable that satellites will be set up around this training center that might be computer terminal centers or equipment repair depots where one could then utilize these skills very quickly.

In order to attract the people—and that is a real, fundamental aspect of it—we have to really attract these young people, and they have to make a commitment. We're going to need a nationally advertised campaign which is going to identify this program, identify it as a joint industry-and-government endeavor, and the bottom line is simple—jobs.

I do not want this program to be government managed under any circumstances. And I want the teaching personnel to come out of industry, because what we have to do is functionally have an industrial environment.

We have community colleges but the problem with community colleges is that they are—an emulation of college, not an emulation of industry. This has got to be an industry-related phenomenon. The people must be taught in a blue collar environment, if I can use that phrase, and they will then learn at the same time good habits as well as the skills to become technical paraprofessionals.

The midrange companies, sir, are ready to make a commitment to this type of program. They have little in the way of alternatives because their future cannot be without the availability of these technical paraprofessionals. And frankly the work force of the future is not going to be muscle and sweat.

The work force of the future will be the application of knowledge, and therefore the commitment of a company will not be to hire educated people, but to educate people throughout their entire work career, because there is no end, sir. Otherwise nothing will move ahead.

That, sir, is my suggestion. That, sir, is my report, and I thank you.

Senator BENTSEN. Your proposals are provided in detail in your prepared statement to be entered in the hearing record?

Mr. WEINIG. Yes, sir, and much better written than spoken. Thank you for the opportunity to testify.

Senator BENTSEN. Thank you, Mr. Weinig.

[The prepared statement of Mr. Weinig follows:]

## PREPARED STATEMENT OF SHELDON WEINIG

I would like to thank you, Senator Bentsen, and the Joint Economic Committee for inviting me to appear today to testify on our Nation's skilled labor shortage.

I am testifying today on behalf of my firm, Materials Research Corporation of Orangeburg, New York, and on behalf of the American Business Conference, a coalition of high-growth, mid-range companies.

I am the President and Chief Executive Officer of Materials Research Corporation, a firm which I founded in 1957. Materials Research Corporation pioneered the basic materials technology used in the production of integrated circuits. We manufacture and sell high purity metals and ceramics to the electronics and telecommunications industries worldwide. We also produce the equipment required for the deposition of the thin films in the manufacture of integrated circuits.

It is appropriate that the Joint Economic Committee venture into the uncharted waters of our Nation's skilled labor shortage as I believe the Committee in the past focused effectively on ignored, but significantly important, problem areas of our economic system.

For example, in hearings you chaired, Senator Bentsen, in the mid-1970s, the Joint Economic Committee identified the productivity problem and urged an increase in capital formation. These issues later became the focal point of the present Administration's economic program.

Your decision to focus on our Nation's skilled labor shortage is very timely. I sincerely hope that public awareness and support are forthcoming. To my mind, the challenge posed to our economic health by our skilled labor crisis is as great as that posed by inadequate capital formation.

As I travel in the United States and read the local newspapers, I am always struck by the number of job openings advertised and announcements of rising unemployment in the same issues of business news. This dichotomy goes to the heart, I believe, of our skilled labor crisis. The manpower is available in this country to fill all the jobs we have. What is not available are the training resources to prepare people for these jobs or the willingness by workers to utilize these training resources.

Let me back up first. Senator Bentsen, you estimated last week that at least 250,000 skilled labor jobs annually go unfilled. I believe the term "at least" is appropriate because your estimate was based on only thirteen occupations —— the largest ones in terms of skilled labor shortage, such as computer operators. If we open that door a little wider, we will find literally hundreds of other occupations of lesser magnitude, occupations most of us have never heard of —— that face acute labor shortages today as well.

I therefore support what you said in your opening remarks regarding the need to develop a much better data base in this entire area. We cannot reasonably expect to develop the necessary programs for ameliorating this skilled labor crisis until we understand the magnitude of the crisis. The only thing we know with certainty now is that it is a serious problem which is going to get worse before it gets better.

I would first like to make some observations regarding the shortages of skilled labor in the United States, both presently and perhaps more importantly relative to the future. I will direct my major remarks and recommendations to technical areas of shortage despite the fact that there may be other critical occupations of a non-technical nature which are similarly affected.

1) There is one very special area of skilled people crying for applicants; this, strangely enough, is the extraordinary shortage of U.S. citizens working toward graduate degrees in engineering and science. It is commendable and certainly desirable to provide advanced technical education to young people from other countries, but unfortunately we are simultaneously producing an insufficient number of technically-trained U.S. citizens who are needed to fill the academic and industrial openings in this country. I repeat, the problem is not the number of foreign students, but rather the insufficient number of U.S. students.

Let's put some numbers to this situation. Approximately 50 percent of all graduate students in our technical graduate student body are foreign. But, a real eye opener is that a number of universities have reported that nearly 80 percent of all new faculty in engineering disciplines are foreign.

To further exacerbate the problem, industry is filling some portion of its shortage of technical personnel by luring professors out of the universities; so we see the age-old phenomenon of courting disaster by eating the "seed corn". This in turn has resulted in a situation where university engineering departments actually lag industry technically, hence producing graduates who are not really up to date in their chosen discipline.

I urge this Committee to consider the entire matter of graduate students and faculty as an extremely serious aspect of the skilled labor shortage. It may well constitute the foundation block for other recommended solutions.

2) Let me now address the specific engineering aspect of the technical labor shortage. This country has an extraordinary shortage of "hands on" engineers. What I am talking about are engineers who are practicing engineering. I do not want to become involved in the controversy as to whether we have too few engineers numerically or too many under-utilized engineers. The fact remains that an extremely large percentage of engineers seek employment upon graduation in areas other than engineering. For example, more engineers go into business schools for MBA degrees than any other category of undergraduate discipline. Interestingly enough, one might expect that this combination of engineering and business would produce a very special talent, but alas, in reality it has not; in fact, it has produced "misfits". The combination simply hasn't worked. This is an area in which it is difficult to produce statistics, but I can assure you it is an opinion held by every CEO I know.

In the specific area of electrical engineering, let us review data relative to the Japanese which will amplify another aspect of the engineering problem.

ANNUAL GRADUATES IN ELECTRICAL ENGINEERING

| | BSEE | MSEE | PhD |
|---|---|---|---|
| Japan | 20,000 | 1,700 | 200 |
| United States | 12,500 | 3,400 | 500 |

In general, Japanese engineering graduates do not go on to advanced training and those who do are specifically studying to become professors. The number who study for anything even resembling an MBA are negligible. So again we see that the United States is not producing a sufficient number of engineers prepared to work in engineering.

However, as I said earlier, the really important area is the "hands on" phenomenon; that is, the critical shortage of practicing engineers. This shortage has been discussed at every level imaginable. Perhaps the most compelling treatise is found in the recent book, THE SOUL OF A NEW MACHINE, by Tracy Kidder, which describes the extraordinary dedication of an engineering team in developing a new computer over an eighteen month period at sacrifice of family, personal life and health.

The bottom line, however, is the literally zero payoff to them at the end of their project, both monetarily and otherwise. In other words, ladies and gentlemen, real engineering doesn't pay in our society; and without the promise of rewards, we cannot expect young people to be attracted into the profession.

3) The most serious area of my concern and what I believe to be the real core problem, both today and for the future, is in the area of "technical paraprofessionals".

A recent U.S. Department of Labor study which considered three assumptions about the growth of the economy predicts areas in which there will be significant skilled labor shortages. These categories were arranged in order of percent change anticipated between the 1978 base and 1990. The three economic scenarios presented each naturally resulted in different growth rates, but fundamentally, the occupational shortage composition remained the same. Shown below are the top six categories for the most conservative growth scenario.

MONTHLY LABOR REVIEW
August 1981
U.S. Department of Labor
Bureau of Labor Statistics

| Occupation | Percent Growth in Employment 1978-1990 |
|---|---|
| Data Processing Machine Mechanics | 147.6 |
| Paralegal Personnel | 132.4 |
| Computer Systems Analysts | 107.8 |
| Computer Operators | 87.9 |
| Office Machine and Cash Register Servicers | 80.8 |
| Computer Programmers | 73.6 |

Of the first six categories, ranging in percent growth from 147.6 percent down to 73.6 percent, five are directly computer-related. It is this type of person who is a technical paraprofessional. We can also include technicians, inspectors, assemblers of complex equipment, drafters, etc.

Many of these jobs are a result of what I have termed the fourth computer revolution. You will recall that the first revoltuion was the main frame; the second was the mini-computer; and the third, the microprocessor, or computer on a chip. Each of these had a significant impact on industry and to some extent on our personal lives, but the fourth revolution, which is the Terminal Revolution (and I hope that isn't prophetic), will place terminals or information gathering and input stations everyplace — home, office, even car. The combination keyboard and CRT (cathode ray tube) readout will truly be an extension of our brains. Printers will be connected only for creating permanent records since voice synthesis can be used to replace the printout. Within the twentieth century, our entire society will deal with a keyboard and a cathode ray tube for all communications. Our daily newspaper will come direct upon command on the CRT or can be printed if we wish to retain a specific article.

At least 50 percent of our existing workforce, including trained engineers, have great difficulty in making the mental transition required by the fourth computer revolution. They are fundamentally afraid of using and/or of being used by the terminal. Anyone who has been involved in a conversion to a terminal base operation knows the trepidation manifested by the personnel involved. Perhaps the real breakthrough will occur in the home when the terminal is used for shopping, paying bills, and even reconciling bank balances. In the home environment, adoption of new technology is far less threatening than in the workplace.

I can't avoid some brief comment on the second largest growth, namely paralegal personnel. This stuns me. The United States already has the highest density of lawyers and legal personnel in the world. The thought that it will grow even more is horrifying. In Japan, one in ten thousand is a lawyer. In the United States, one in four hundred and fifty is a lawyer. In Washington and New York, every other person is a lawyer. Enough is enough!

Ladies and gentlemen, what are we to do about this present and even greater future shortage of technical paraprofessionals? These are "hands on" people with specialized skills that are not simply learned on the job. They must be trained. I believe the problem begins in the high schools. Our secondary schools are college oriented. The special high school that is not college oriented has, for the most part, become a holding pen for those students being forced to put in the requisite number of years of secondary education.

The non-college bound youngster coming out of our school system has no skills, and more importantly, has no expectations. It is this group that must be addressed relative to developing the large number of technical paraprofessionals. Fundamentally, our job is to identify, inspire and train these young people.

What we don't want is for the Government to manage these training programs. Furthermore, these programs should be used for youngsters who are ready to learn. The teaching of technological skills requires a student's commitment and a willingness to adapt to the workplace requirements.

The significant growth and demand for technical paraprofessionals has occurred in the mid-range companies, those represented by the American Business Conference. Large companies have not experienced meaningful growth. Government assistance for these training programs should be geared to these mid-range companies and their unique requirements.

Training tax incentives are required, while allowing industry to manage the programs. For example, many mid-range companies do not have the "bricks and mortar" of large companies or even academia. Therefore, one possibility might be a coalition of companies in a geographic area utilizing a facility owned by government or a local school. The teaching equipment should be "state of the art", and some form of assistance would be meaningful. Teaching personnel could best be supplied by the participating companies.

This type of "coalition of companies" training should be patterned after industry, not academia. One failure of community colleges is that they attempt to emulate colleges; they created "poor man's two-year colleges". A good example of the industry-related approach is The Rochester Institute of Technology in Rochester, New York, which was set up with an EDA $3.5 million matching grant. They began teaching machine tool trades and have now expanded to drafting.

Their students "punch in" in the morning, have a 40-minute lunch, and "punch out" at the end of the day. They are closely supervised during the training day and develop work habits. RIT's program is conducted in a blue-collar environment. Every graduate of RIT has been placed in a job; in fact, even the failouts have gotten jobs.

A second approach to using private sector incentives for training technical paraprofessionals would be on actual company premises. The argument that it interferes with production is real, but the benefits derived from direct involvement and the smooth transition into the company programs is a positive factor. However, mid-range companies require help in establishing and maintaining programs of this type on their own premises. We are not speaking about apprentice-style programs, but rather the training of significant numbers of people with full time dedicated instructors.

At MRC we have a "no layoff" policy and this necessitates that people be moved from job to job, possibly requiring different skills. We also have complete educational reimbursement; however, it doesn't fill the need of the former since the educational program is used primarily by employees involved in undergraduate or graduate college level programs.

We also have a New York State job incentive program funded in the form of tax credits. It was initiated when we built a new building. We selected machine tool training from a State-developed curriculum for 42 occupations. It is essentially an apprentice program. It is simple and effective, but does not train technical paraprofessionals.

Therefore, despite a number of company and local government programs, there remains a significant need that could and should be filled at the Federal level. I believe the investment will be modest compared to the potential results.

What I am recommending is a combination program that will provide tax incentives to companies for training people in special skills leading to careers as technical paraprofessionals. The programs may function on-site or in cooperation with other companies at off-site coalition training centers. These centers can be located near areas of potential job candidates or even within cities. As people are trained, satellite operations could be established at inner-city sites that will utilize these special skills. The satellites could be storefront terminal centers for data processing, equipment repair depots, etc. In order to attract the young people to the program, a nationally advertised campaign is necessary, identifying the program as a joint industry and Government endeavor.

The mid-range companies are ready to make a commitment to the program as they really have little in the way of alternatives. Their planned futures cannot be without a continuing supply of technical paraprofessionals. With assistance in the form of tax incentives to overcome the initial setup costs and some form of ongoing training assistance, I believe that the program can make serious headway toward eliminating a major portion of the skilled labor shortage.

####

Senator **Bentsen**. Let me make one comment. You talk about terminals at the office and at home, and how you think becoming familiar with them will be easier in the home. I suppose part of that is related to the fear of failure by a person at the office, where it is so apparent. You can blow it at home and finally work it out without embarrassment.

Mr. **Weinig**. That's absolutely true.

Senator **Bentsen**. Our next witness is W. Paul Cooper. Mr. Cooper, proceed, sir, please. We are pleased to have you.

## STATEMENT OF W. PAUL COOPER, CHAIRMAN OF THE BOARD, ACME-CLEVELAND CORP., CHAIRMAN, GOVERNMENT RELATIONS COMMITTEE, AND VICE CHAIRMAN OF THE NATIONAL MACHINE TOOL BUILDERS' ASSOCIATION, McLEAN, VA., ACCOMPANIED BY JOHN MANDL, TRAINING DIRECTOR

Mr. **Cooper**. Thank you. I am Paul Cooper, chairman of the board of Acme-Cleveland Corp., and not an engineer. [Laughter.]

With me is John Mandl, training director, of the National Machine Tool Builders' Association.

NMTBA is a trade association representing about 400 manufacturers of machine tools in 33 States that account for approximately 90 percent of U.S. production.

Employment in the industry is presently around 100,000 people. A major portion of the machine tool industry's work force consists of highly skilled machinists, assemblers, and maintenance personnel. These occupations do not require a college degree but require about the same amount of time as a college education to achieve the required skills and be proficient on the job.

Teaching these skills through formal apprenticeship programs, cooperative education programs, and on-the-job training programs are desirable methods of creating the qualified people needed for the future.

But disruptions occur in that process. Due to the cyclical nature of our industry, many young workers are subject to occasional layoffs as dictated by seniority rules. Some don't return but pursue other occupations. As a result, the kind of skilled work force we need is in short supply during expansion years. Obviously, smoothing the peaks and valleys of business cycles would do much to maintain a stable work force.

But that's not the only problem that affects us. Other factors include:

The shift to white collar and service jobs.

The statistical projections of the declining number of workers age 18–25, and declining school enrollments will have an impact on the work force in general, not just in metalworking.

A perception by too many people that working in a factory is a low rung on the occupational choice ladder and that industrial work is in conflict with occupations which help people.

Also, I believe there is a lack of effective career guidance in public schools toward industrial work.

Another factor tending to divert students from potential industrial work has been excessive emphasis on students to enter college, just for the sake of going to college. Believe me, we need college-trained engineers in electronics, manufacturing, and design as desperately as we need anyone else. But in terms of sheer numbers, we need proportionately more people in the skilled trades.

Many of us in our industry are working to encourage more people, young people to go into manufacturing engineering. That's the art of how do you make it, because here again is a current shortage.

Our schools have yet to produce finished products, that is, graduates, who can become productive without extensive on-the-job training at considerable cost to the employer. Most large employers accept this responsibility as the cost of doing business. Indeed, much state of the art technical training must be done by the employer. Many small employers either cannot, or do not, provide this training because of the financial overhead involved and the drain on skilled workers who have to do the teaching.

Temporary measures used by many companies to overcome shortages of skilled people include, one, maintaining the current work force and stretching out delivery time with a resultant flow of imports to fill the gap; two, simplifying jobs by breaking the task into components that can be handled by relatively less skilled people; three, hiring foreign skilled workers; four, utilizing skilled people through more overtime work; and five, pirating skilled people from other companies.

The practice of crash hiring of skilled workers to fulfill a contract within a specified timeframe obviously drives up wage costs and causes problems for the companies that lose skilled people.

None of these measures builds up or insures a skilled work force for the future or significantly contributes to the pool of craftsmen needed by the Nation. It exacerbates our competitive disadvantage with other countries.

The House Armed Services Committee report of December 30, 1980, on the defense industrial base has estimated that the Nation would be short 250,000 skilled machinists by 1985. The Department of Labor's projections from 1979 emphasized the need for 23,000 new skilled machinists each year for the next 10 years.

In a period of economic slowdown or stagnation as some segments of industry are experiencing right now, it is easy to ignore or minimize future needs. But considering that it takes 3 or 4 years to train skilled people we cannot afford to reduce our technical and apprenticeship programs in slow times and expect to have enough craftsmen in the future. And yet we do this in many cases, all too often, because of the significant costs involved.

Each trainee involves the cost of lost productivity during the early learning stages; trainee wage costs and costs of support personnel doing the training, and facility and equipment costs which add up to a substantial investment. This investment is typically in the range of $25,000 to $40,000 for each 4-year apprenticeship program.

And if we do not have the people, or pay the training costs, who will operate, maintain and support the reindustrialization process in the future? What would happen if we had to expand our productive capacity immediately because of a national emergency?

The industrial might of America, for those of us not directly engaged in those activities, is largely taken for granted. It's thought to be "just there."

But it won't be there forever unless we pay attention to our industrial base.

We are all familiar with the loss of jobs and technical superiority in the manufacture of radios, television sets, watches, automobiles, tires, and other products. This could also happen to the machine tool industry—an industry vital to national defense—if we do not do everything possible to improve our competitiveness in world markets.

Positive actions taken by the association to improve its human resources position in the face of these negative factors include working closely with the Vocational Industrial Clubs of America in supporting their goals and activities. VICA is a youth organization of over a quarter of a million members in high schools and technical schools across the country. This organization represents a successful effort to instill in their members the twin goals of pride in work and good citizenship.

VICA sponsors State and regional competitions each year to determine the best students in a variety of occupational pursuits such as auto mechanics, bricklaying, electronics, welding, metalworking, and 30 other occupations. The winners of State and regional contests then compete in a national competition called the U.S. Skill Olympics, which will be held in Louisville, Ky. next June. Over 7,000 students and visitors attended the last Skill Olympics held this year in Atlanta, Ga.

Additionally, the VICA organization sponsors an International Skill Olympics which was held in conjunction with the U.S. Skill Olympics this year.

This year the three top winners in the machinist competition in the international event were from Korea, Japan, and Taiwan.

Perhaps that is an indication of the emphasis those countries are placing on training youth for industry, and perhaps a warning to us that we don't want our sons and daughters to be skilled machinists that there are plenty of foreign workers willing and able to take over these jobs for us.

We are making a continuing effort to accelerate programs that make people aware of the challenging career opportunities available in manufacturing. The association has increased its effort in this area by expanding the scope of our promotional efforts on the industry's behalf.

These activities are a part, albeit small, of the long-term solution to the chronic skills shortage. Many other things have to be done, and there is no single program or policy that will be a cure-all.

For example, the efforts that the military establishment is making in introducing apprenticeship programs is supported by everyone I know involved with industrial training.

Senator BENTSEN. Let me interrupt a minute. What kind of budget does the association have for this promotional effort on behalf of the industry—for the films showing career opportunities transmitted over cable TV? How much money are we talking about being dedicated to that effort?

Mr. COOPER. John, what would you estimate?

Mr. MANDL. Yes, sir, if I may answer that. The current film budget is $186,000.

Senator BENTSEN. Gentlemen, one media campaign for one Congressman is more than that. That is not much money in this day and time. But it is certainly needed.

Mr. COOPER. I should point out we're a relatively small industry.

Mr. MANDL. Senator, let me point out that the funds we are talking about are for production costs only. In that light, this compares favorably with the production cost budgets of most congressional campaigns. Media costs, as you know, are a different and more expensive budget item. The film will be available to schools and cable television, as well as for the use of our own members. Our association's distribution costs will average about $35,000 per year. In addition, our members will make a significant contribution to the distribution of this film.

Mr. COOPER. The Department of Defense has long had a program directed toward improving skills training by loaning machinery to Schools through its "Tools for Schools" program. More emphasis on this program, and updating of the equipment made available to schools should be explored as one additional step toward assuring a skilled work force. In addition, bureaucratic regulations make it fairly difficult to transfer equipment to qualified training institutions. I had indications in discussions before the meeting that they now are being eased.

The U.S. Department of Labor had supported skills training activities for many years, first through the Manpower Development and Training Act and then through the Comprehensive Employment and Training Act, CETA. NMTBA has participated in these programs as a contractor with the Department of Labor. About 15,000 people have been trained through on-the-job training programs over the years at an average cost to the taxpayer of less than $1,000 per trainee. These programs have helped to alleviate what has proven to be a persistent skills shortage problem, the discrepancy between the skilled jobs available to be filled and the lack of qualified persons to fill those jobs, but the program has not solved it.

If there is a rationale for Federal involvement in private sector training activities it is to make up for the shortfall in the quantity and educational quality of students, who, having been processed through the public educational system still do not, in the needed numbers, possess sufficient educational skills to take advantage of the on-the-job training offered by employers in skilled occupations.

I fully appreciate that the public school system does not exist merely to provide candidates for industry. But whether industry should be expected to perform functions which could have been accomplished through our publicly financed schools is a matter for serious public discussion. Basic education is currently being supplied by industry at a considerable expense, not the least of which is a loss of productivity and competitiveness during this remedial training period.

Some policy options which might be considered in the resolution of these problems include one, improving quality control in our publicly financed educational system to the point that the finished products of that system, the students, can be absorbed into private industry without remedial education; two, during the time this improvement in the educational system is taking place, private industry should be supported in providing technical education through appropriations or training tax credits, especially for critical occupation skills areas anticipated to be in short supply during the 1980's; and three, industry should be expected to provide all postsecondary technical education on its own. This is a most laudable position, but one made most difficult in light of the negative factors previously cited. To do nothing is to exercise their option.

In conclusion, I would point out that in order to stay competitive in maintaining a viable industrial base, we must provide support for training in the private industrial sector.

A priority should be established to emphasize occupational opportunities in the Nation's defense/industrial base, in order to influence and direct more students into the technical fields that support industrial growth, and would provide a pool of technically trained people needed in any emergency. While I am not suggesting a World War II campaign in which we make a heroine of "Rosy the Riveter" or introduce slogans like "Keep'em Flying," some emphasis along this line is needed.

Every student who graduates from high school should have a solid mathematics and science background. This is knowledge that will allow them to be more rapidly absorbed into the work force and enable an employer to train and make its employees more productive sooner.

Indeed, the exposure to mathematics and the sciences in high school may be the spark that ignites the student's interest toward careers in manufacturing, where all these skills are used daily on a practical basis.

We must improve the image of vocational education and place more emphasis on occupational training where people can work both with their hands and their minds. Legislation affecting vocational education is being considered now under the reauthorization of the Vocational Education Act. All of us are concerned with the future education of youngsters in occupational training and should take an interest in the specifics of that reauthorization bill to be sure that it supports the kinds of activities that will insure a steady flow of well-rounded students into industry.

Thank you very much. I too will be happy to answer questions.

Senator BENTSEN. Thank you, Mr. Cooper and Mr. Mandl.

[The prepared statement of Mr. Cooper follows:]

## PREPARED STATEMENT OF W. PAUL COOPER

### 1. INTRODUCTION

NMTBA is a Trade Association representing about 400 manufacturers of machine tools in 33 states that account for approximately 90% of U. S. production. The industry contains a large number of very small businesses. There are only 9 establishments with 1,000 or more employees, and 36 with 500 or more employees. Most of the remaining machine tool manufacturers throughout the country can be classified as truly small businesses.

Employment in the industry is presently around 100,000 people. A major portion of the machine tool industry's workforce consists of highly skilled machinists, assemblers, and maintenance personnel. These occupations do not require a college degree but require about the same amount of time as a college education to achieve the required skills and be proficient on the job.

## II. THE DECLINING WORKFORCE

Teaching these skills through formal apprenticeship programs, cooperative education programs and on-the-job training programs are desirable methods of creating the qualified people needed for the future. But disruptions occur in that process. Due to the cyclical nature of our industry, many young workers are subject to occasional layoffs as dictated by seniority rules. Some don't return, but pursue other occupations; as a result, the kind of skilled workforce we need is in short supply during expansion years. Obviously, smoothing the peaks and valleys of business cycles would do much to maintain a stable workforce.

As an example, the recession of 1970-1971 was a depression for our industry because we lost 25% of our workforce in that time period. Some companies eliminated their training completely - others reduced the number of apprentice trainees hired. The rebuilding of our reserves of skilled craftsmen has been improving since that time despite additional cyclical changes in the economy which affect our industry.

But that's not the only problem that affects us. Other factors include:

The shift to white collar and service jobs. These jobs are more widely available, they exist where manufacturing is located and where it is not located, providing easy accessibility to the job market and attracting many potential employees away from industry.

The statistical projections of the declining number of workers age 18-24, and declining school enrollments will have an impact on the workforce in general, not just in metalworking. We cannot ignore this important fact in workforce planning in the near future, as it will compound an already serious problem.

A perception by too many people that working in a "factory" is a low rung on the occupational choice ladder and that industrial work is in conflict with occupations which "help" people.

These perceptions are real in the minds of many people and are perpetuated by the attitude, "I don't want my children to work in a factory", or, "If you are not a good student you can always transfer to the vocational education program."

I don't know any slow-witted tool and die makers or machine repair technicians, or people in a dozen other "factory" jobs I could mention. They are highly skilled, intelligent people who may or may not have a college background. But they are well educated. Their education includes public school and training through apprenticeship programs or some other combination of on-the-job training and related instruction provided by private industry.

## III. ROLE OF THE PUBLIC SCHOOL

Also, I believe there is a lack of effective career guidance in public schools toward industrial work. Can one entirely blame counselors for not guiding enough students to industrial occupations? I think not. It is expecting too much of school counselors to have an in-depth knowledge of hundreds of occupations and to effectively match the "right" student with the "right" job. Therefore, it behooves industry to be even more active in career day activities, promoting occupational opportunities through films, brochures, providing speakers, and arranging plant tours in order to expose students and counselors to the real world of occupational career choices.

Another factor tending to divert students from potential industrial work has been excessive emphasis on students to enter college, just for the sake of going to college.

A factor perhaps in decline as the cost of a college education increases and the perception spreads that other avenues toward a rewarding life style exist through other occupations where you can "earn as you learn." Believe me, we need college trained engineers in electronics, manufacturing, and design as desperately as we need anyone else. But in terms of sheer numbers, we need proportionately more people in the skilled trades.

Our schools have yet to produce finished products, i.e., graduates, who can become productive without extensive on-the-job training at considerable cost to the employer. Most large employers accept this responsibility as "the cost of doing business." Indeed much "state of the art" technical training must be done by the employer. Many small employers either cannot, or do not, provide this training because of the financial overhead involved and the drain on skilled workers who have to do the teaching.

## IV. TEMPORARY MEASURES

Temporary measures used by many companies to overcome shortages of skilled people include: (1) Maintaining the current workforce and delaying delivery time with a resultant flow of imports to fill the gap; (2) Simplifying jobs by breaking tasks into components that can be handled by relatively unskilled people; (3) Hiring foreign skilled workers;

(4) Utilizing skilled people through more overtime work; and (5) Pirating skilled people from other companies. The practice of crash hiring of skilled workers to fulfill a contract within a specified time frame obviously drives up wage costs and causes problems for the companies that lost skilled people.

None of these measures builds or insures a skilled workforce for the future or significantly contributes to the pool of craftsmen needed by the nation. It exacerbates our competitive disadvantage with other countries.

## V. SHORTAGE PROJECTIONS

The House Armed Services Committee Report of December 30, 1980, on the defense industrial base has estimated that the Nation would be short 250,000 skilled machinists by 1985. The Department of Labor's projections from 1979 emphasized the need for 23,000 skilled machinists each year for the next 10 years.

During the past when military requirements necessitated, we were able to build machine tools virtually in any type of manufacturing plant with people whose mechanical skills could be quickly converted to the industry's requirements; but today, given the complexity, sophistication and high precision of today's machinery, that is almost impossible.

Our current industry projections based on labor force growth of above 4% per year to 1985 would cause an increase in production workers in metalcutting from 47,500 to 55,500 (a net increase of 8,000). This does not take into account extraordinary production needs such as those that might be required by prime contractors under the increased defense budget. Nor do these figures take into account additional workers needed in the metalforming segment of our industry.

During the Korean War build-up (1949-1952) the metalcutting production workforce in our industry doubled from 38,500 to 79,000. The sustained economic growth in the 1960's and our Vietnam involvement again almost doubled the production workforce in metalcutting. If we were expected to again double our workforce or even substantially increase production, the negative factors affecting our industry would come into full play.

In a period of economic slow-down or stagnation, as some segments of industry are experiencing right now, it is easy to ignore or minimize future needs. But considering that it takes 3 or 4 years to train skilled people we cannot afford to reduce our technical and apprenticeship programs in slow times and expect to have enough craftsmen in the future. And yet we do this in many cases, all too often, because of the significant costs involved.

Each trainee involves the cost of lost productivity during the early learning stages; trainee wage costs and costs of support personnel doing the training, and facility and equipment costs which add up to a substantial investment. This investment is typically in the range of $25,000 to $40,000 for a 4 year apprenticeship program.

And if we do not have the people, or pay the training costs, who will operate, maintain and support the re-industrialization process in the future? What would happen if we had to expand our productive capacity immediately because of a national emergency?

The industrial might of America, for those of us not directly engaged in those activities, is largely taken for granted. It's just there.

But it won't be there forever unless we pay attention to our industrial base.

We are all familiar with the loss of jobs and technical superiority in the manufacture of radios, television sets, watches, automobiles, tires and other products. This could also happen to the machine tool industry - an industry vital to national defense - if we do not do everything possible to improve our competitiveness in world markets.

When jobs are lost, some skilled people do pack up and move to where work is available, but obviously this doesn't happen often enough or fast enough to keep the labor force in equilibrium. People are more apt to stay where they are while waiting for job prospects to improve. Breaking family ties, coupled with housing problems and the uncertainties of starting a career over again in a new environment, mitigates against a migratory skilled workforce.

## VI. ATTRACTING NEW TRAINEES

Positive actions taken by the Association to improve its human resources position in the face of these negative factors include working closely with the Vocational Industrial Clubs of America (VICA) in supporting their goals and activities. VICA is a youth organization of over a quarter of a million members in high schools and technical schools across the country. This organization represents a successful effort to instill in their members the twin goals of pride in work, and good citizenship.

## VII. VOCATIONAL TRAINING

VICA sponsors state and regional competitions each year to determine the best students in a variety of occupational pursuits such as auto-mechanics, bricklaying, electronics, welding, metalworking, and 30 other occupations.

The winners of state and regional contests then compete in a national competition called the United States Skill Olympics, which will be held in Louisville, Kentucky next June. Over 7,000 students and visitors attended the last Skill Olympics held this year in Atlanta, Georgia. Through involvement with VICA, we have established liaison with hundreds of vocational educators. This has had a positive impact on improving metalworking education.

Additionally, the VICA organization sponsors an International Skill Olympics which was held in conjunction with the United States Skill Olympics this year.

This year the three top winners in the machinist competition in the international event were from Korea, Japan and Taiwan. Perhaps that is an indication of the emphasis those countries are placing on training youth for industry, and perhaps a warning to us that if we don't want our sons and daughters to be skilled machinists that there are plenty of foreign workers willing and able to take over these jobs for us.

We are making a continuing effort to accelerate programs that make people aware of the challenging career opportunities available in manufacturing. The Association has increased its effort in this area by expanding the scope of our promotional efforts on the industry's behalf. A new film on career opportunities in the industry is being developed.

This film will be used by Association staff and individual member companies in employee recruitment efforts. It will also be available for presentation on cable television to reach adult viewers, especially parents who can influence their children's perception of industrial work. These activities are a part, albeit small, of the long term solution to the chronic skills shortage. Many other things have to be done, and there is no single program or policy that will be a cure-all.

The adoption of a variety of programs and policies that will have an impact on the educational system, the minds of parents, and the interests of potential employees in manufacturing must be developed over a broad base.

## VIII. MILITARY TRAINING PROGRAMS

For example, the efforts that the military establishment is making in introducing apprenticeship programs is supported by everyone I know involved with industrial training. They should be expanded. Information from the Bureau of Apprenticeship and Training, U. S. Department of Labor, shows that 26,833 apprentices are enrolled in the Army program, 416 in the Navy and 712 in the Marine Corps. The military apprenticeships cover 72 occupations, many of which have direct private sector industrial application such as machinists, welders, sheet metal workers and electronic technicians.

The written standards or occupational task training outlines that are carried by apprentices were developed with private sector industrial input so that they would be easily translated and comparable to civilian terminology. As the military apprentices are trained and receive experience in the various tasks within their occupation, the successful completion of these tasks is recorded in the apprentices' log book. Because of other military duties, most apprentices will not complete the full apprenticeship program in a 3 or 4 year enlistment.

This fact serves as an additional inducement for re-enlistment. For those apprentices who do not re-enlist, their log book is a permanent record of their experiences and helps them in obtaining employment in the private sector.

This documentation of skills learned in the service is valuable information for employers. The fact that the person was enrolled in a specific skills program shows that person's interest in the field and encourages them to seek further training in that field after separation. Recognition of skills achieved while in the service has the effect of substantially reducing the training expense of the employing company, because it eliminates duplication of training.

Additionally, the Department of Defense has long had a program directed toward improving skills training by loaning machinery to schools through its Tools for Schools program. More emphasis on this program, and updating of the equipment made available to schools should be explored as one additional step toward assuring a skilled workforce. In addition, bureaucratic regulations make it fairly difficult to transfer equipment to qualified training institutions. These regulations should be eased.

## IX. FEDERAL INVOLVEMENT IN TRAINING PROGRAMS

The U. S. Department of Labor has supported skills training activities for many years, first through the Manpower Development and Training Act and then through the Comprehensive Employment and Training Act (CETA). NMTBA has participated in these programs as a contractor with the Department of Labor. About 15,000 people have been trained through on-the-job training programs over the years at an average cost to the taxpayer of less than $1,000 per trainee. These programs have helped to alleviate what has proven to be a persistent skills shortage problem (the discrepancy between the skilled jobs available to be filled and the lack of qualified persons to fill those jobs), but has not solved it.

If there is a rationale for federal involvement in private sector training activities it is to make up for the shortfall in the quantity and educational quality of students, who, having been processed through the public educational system still do not, in the needed numbers, possess sufficient educational skills to take advantage of the on-the-job training offered by employers in skilled occupations. I fully appreciate that the public school system does not exist merely to provide candidates for industry. But whether industry should be expected to perform functions which could have been accomplished through our publicly financed schools is a matter for serious public discussion. Basic education is currently being supplied by industry at a considerable expense, not the least of which is a loss of productivity and competitiveness during this training period.

## X. POLICY OPTIONS

Some policy options which might be considered in the resolution of these problems include: (1) Improving quality control in our publicly financed educational system to the point that the finished products of that system, the students, can be absorbed into private industry without remedial education; (2) During the time this improvement in the educational system is taking place, private industry should be supported in providing technical education through appropriations or training tax credits, especially for critical occupational skills areas anticipated to be in short supply during the 1980's;

and (3) Industry should be expected to provide all post-secondary technical education on its own. This is a most laudable position, but one made most difficult in light of the negative factors previously cited. To do nothing is to excercise the third option.

## XI. CONCLUSION

In conclusion, I would point out that in order to stay competitive in maintaining a viable industrial base we must provide support for training in the private industrial sector. A priority should be established to emphasize occupational opportunities in the nation's defense industrial base in order to influence and direct more students into the technical fields that support industrial growth and would provide a pool of technically trained people needed in any emergency. While I am not suggesting a World War II campaign in which we make a heroine of "Rosy the Riveter" or introduce slogans like "Keep 'em Flying", some emphasis along this line is needed.

Every student who graduates from high school should have a solid mathematics and science background. This is knowledge that will allow them to be more readily absorbed into the workforce and enable an employer to train and make its employees more productive, sooner.

Indeed, the exposure to mathematics and the sciences in high school may be the spark that ignites the student's interest toward careers in manufacturing, where all these skills are used daily on a practical basis.

We must improve the image of vocational education and place more emphasis on occupational training where people can work both with their hands and their minds. Legislation affecting vocational education is being considered now under the re-authorization of the Vocational Education Act. All of us who are concerned with the future education of youngsters in occupational training should take an interest in the specifics of that re-authorization bill to be sure that it supports the kinds of activities that will insure a steady flow of well-rounded students into industry.

Senator **Bentsen**. Mr. Cooper, my problem is I have a critical markup in the Public Works Committee on the Clean Air bill taking place right now. And, I am going to have to leave shortly for that.

I think what you gentlemen have brought to us has been extremely helpful. There seems to be a common theme running through each of your statements that technical and craft occupations have a public image such that people going to high school do not look forward to hands-on work. Somehow we have to turn that around.

I think what you are trying to do Mr. Cooper, is fine. I think the amount of commitment could be larger. You have to get much more involved than that. You and Mr. Weinig noted that the bulk of our high school graduates have few, if any, marketable skills upon graduation. At the same time we see parents spending thousands of dollars on college educations, which are extremely expensive these days. Yet, once they graduate, many have few marketable skills either. That is in direct contrast with the educational systems of other countries, such as the earlier cited Japanese and German systems.

Mr. **Cooper**. Senator, I might point out that individual companies in our association are working at the local level. We, for example, have contributed thousands of dollars of machine tools to the vocational education schools in the city of Cleveland, provided supplies, instructors, and helped with curriculum development. But we can't expect the association to carry the whole ball.

Senator **Bentsen**. I understand, and compliment your program.

Mr. **Cooper**. I know other companies in the association are working at the local level.

Senator **Bentsen**. I think one point the public has to understand is that when we talk about career-oriented programs today, the skills we are talking about are not the kind of skills we were talking about 30 years ago.

Mr. Weinig, in particular has pointed that out. The sophistication and challenge required today is far above that required of youths in the past. I know that from my own experience on terminals. I think I have had a reasonable education. But, it was very time consuming trying to fully understand all the techniques and skills needed to put a terminal to effective use.

What we are talking about today is something that is a real test of ones knowledge. The skill is not just being able to turn a wrench. Yet, I think the rewards are much higher, as well—a message we must try to get across.

I am particularly appreciative of your suggestions which I will study further. Your testimony has been very informative and persuasive. This is not a problem to be solved just by government, although I think Government can be helpful.

I think the primary responsibility is with industry and our existing educational system. The Federal Government can efficiently complement these other two sectors, and I want to see that we do it. But it is not a problem to be solved just by throwing tax dollars at it.

Mr. **Willenbrock**. If I may interject. Mr. Vice Chairman, the recent activity you had with regard to the R. & D. tax credit, for example, is a perfect example of how the Government can take an action to facilitate a university-industry connection.

Senator **Bentsen**. We put an incentive in there specifically to assist universities. It will be helpful, and we will see how much industry takes advantage of that carrot. I hope they really go after it.

Gentlemen, thank you very much for your contribution. It has been very helpful to us. The subcommittee is adjourned.

[Whereupon. at 11:15 a.m., the subcommittee adjourned, subject to the call of the Chair.]

[The following information was subsequently supplied for the record:]

## STATEMENT OF THE NATIONAL TOOLING & MACHINING ASSOCIATION
## WASHINGTON, D.C.

THE NATIONAL TOOLING AND MACHINING ASSOCIATION REPRESENTS 12,500 COMPANIES AND 250,000 WORKERS IN THE UNITED STATES. FOR THE MOST PART, NTMA MEMBERS ARE SMALL BUSINESSES, YET THE INDUSTRY GENERATES SALES IN EXCESS OF $19 BILLION A YEAR. OUR MEMBERS DESIGN AND MANUFACTURE TOOLS, DIES, JIGS, FIXTURES, GAGES, SPECIAL MACHINES, AND PRECISION PRODUCTION PARTS. SOME FIRMS SPECIALIZE IN EXPERIMENTAL RESEARCH AND DEVELOPMENT WORK.

THE TOOLING AND MACHINING INDUSTRY IS CRITICAL TO OUR COUNTRY'S HEALTH AS IT MAKES POSSIBLE THE EXISTENCE OF VIRTUALLY EVERY OTHER MANUFACTURING INDUSTRY. TOOLING IS, IN ITS SIMPLEST SENSE, THE MEANS OF PRODUCTION. IN ITS CURRENT MODERN INDUSTRIAL USAGE, TOOLING REFERS TO THE SPECIAL, OFTEN ONE-OF-A-KIND DESIRED LEVELS OF UNIFORMITY, ACCURACY, INTER-CHANGEABILITY, AND QUALITY. IT INCLUDES SEVERAL MACHINE TOOLS OR MACHINING SYSTEMS WHICH SERVE A SPECIFIC FUNCTION OR SERIES OF FUNCTIONS RELATED TO THE MANUFACTURE OF SPECIFIC END PRODUCTS. MACHINING INVOLVES THE USE OF MECHANICAL, ELECTRICAL, CHEMICAL, AND PHOTO-OPTICAL TECHNIQUES TO FORM MATERIAL, USUALLY METAL, UNDER PRECISELY CONTROLLED CONDITIONS.

AT THE CORE OF THE INDUSTRY ARE THE MOST HIGHLY SKILLED WORKERS IN THE COUNTRY. A JOURNEYMAN MUST COMPLETE A FOUR-YEAR APPRENTICESHIP REQUIRING 576 HOURS IN THE CLASSROOM AND 8,000 HOURS OF ON-THE-JOB TRAINING.

OUR INDUSTRY SUPPLIES THE NECESSARY PRECISION TOOLING AND MACHINING FOR SUCH VITAL INDUSTRIES AS DEFENSE, AUTOMOTIVE, AEROSPACE, APPLIANCE, BUSINESS MACHINES, ELECTRONICS, AGRICULTURAL IMPLEMENTS, ORDNANCE, TRANSPORTATION, ENVIRONMENTAL, CONSTRUCTION EQUIPMENT, NUCLEAR, AND MANY MORE. IN POINT OF FACT, NEARLY EVERY MANUFACTURER DOES BUSINESS AT ONE TIME OR ANOTHER WITH THE CONTRACT TOOLING AND MACHINING INDUSTRY.

APPROXIMATELY 20 PERCENT OF OUR MEMBERS DO WORK FOR THE DEPARTMENT OF DEFENSE, MOSTLY ON PARTS AT THE SUBCONTRACTOR LEVEL. .

OTHER MEMBERS PRODUCE TOOLING FOR PRIME CONTRACTORS. AN ACUTE PROBLEM FOR THE DEFENSE SUBCONTRACTOR, AS WELL AS THE PRIVATE INDUSTRY CONTRACTORS IN OUR INDUSTRY, IS AN ACUTE SHORTAGE OF SKILLED LABOR, BOTH FOR TOOLING AND PARTS. THE IMPLICATIONS OF THIS SHORTAGE ARE DIRE, BOTH FOR DEFENSE PROCUREMENT, AS WELL AS THE OVERALL U.S. INDUSTRIAL BASE.

IN A 1980 REPORT OF THE DEFENSE INDUSTRIAL BASE PANEL OF THE HOUSE COMMITTEE ON ARMED SERVICES, CHAIRMAN MEL PRICE CONCLUDED THAT, "IN THE EVENT OF A WAR, THE U.S. DEFENSE INDUSTRY WOULD FIND IT ALMOST IMPOSSIBLE TO EXPAND ITS WEAPONS PRODUCTION SUDDENLY AND DRAMATICALLY IN THE NUMBERS NECESSARY TO SUSTAIN A PROLONGED CONFLICT." IN THE SAME REPORT, THE DEFENSE SCIENCE BOARD TASK FORCE CONCLUDED THAT A MAJOR CONTRIBUTOR TO THE INCREASING LEAD TIME AND COST CURRENTLY AFFECTING THE DEFENSE SUB-COMMUNITY IS A CONTINUING SHORTAGE OF SKILLED LABOR AMONG SMALL BUSINESS SUBCONTRACTORS. "IT IS CLEAR THAT THE SHORTAGES OF MACHINISTS AND OTHER SKILLED LABORERS ARE CONTRIBUTING FACTORS WHICH ADVERSELY AFFECT THE ABILITY OF THE SUB-TIER BASE TO RESPOND RAPIDLY TO SIGNIFICANT INCREASES IN DEFENSE PRODUCTION DEMANDS."

IF ANYTHING, THIS REPORT MAY BE UNDERSTATING THE PROBLEM. AN INDUSTRY BASE SURVEY CONDUCTED BY NTMA IN 1980 SHOWED A SHORTAGE OF 60,000 SKILLED WORKERS RIGHT NOW WITH A DEMAND EXPECTED TO CLIMB TO 250,000 ADDITIONAL WORKERS BY 1985. UNLESS THIS CRITICAL SKILLED LABOR SHORTAGE IS ADDRESSED, WE WILL FIND THAT MAJOR WEAPONS SYSTEMS WILL FACE COSTLY AND TIME-CONSUMING DELAYS AS THEY MUST WAIT IN TURN

FOR THE SPECIALIZED, HIGHLY-SKILLED SERVICES OF ONE OF OUR SUBCONTRACTORS. IN A PEACETIME ECONOMY, THEY WILL BE COMPETING AGAINST PRIVATE INDUSTRY, WHICH WILL BE BUILDING NEW ASSEMBLY LINES AS A RESULT OF THE INCENTIVES FOR BUSINESS INVESTMENT PROVIDED IN THE PRESIDENT'S TAX PACKAGE.

WE BELIEVE THE SHORTAGE OF SKILLED LABOR IS NOT RELATED TO WAGES PAID TO WORKERS. A SKILLED JOURNEYMAN EARNS BETWEEN $25,000 AND $40,000. INSTEAD, WE FEEL THE SHORTAGE IS CAUSED BY OTHER ECONOMIC FACTORS WHICH MAKE THE COST OF TRAINING THE HIGHLY SKILLED INCREASINGLY UNAFFORDABLE TO SMALL COMPANIES:

1. THE COST OF TRAINING THE HIGHLY SKILLED WORKERS FOR THIS INDUSTRY IS EXTREMELY HIGH. THE COST INCLUDES A CAPITAL INVESTMENT OF BETWEEN $40,000 AND $60,000 PER WORKER AND 4 YEARS OF TIME WHILE THE WORKER COMPLETES THE APPRENTICESHIP.

2. MOST COMPANIES IN SMALL BUSINESS INDUSTRIES ARE HIGHLY COMPETITIVE. THE RELATIVELY MODEST PROFITS, SMALL SIZE, AND LACK OF SPECIALIZATION DO NOT AFFORD THE LUXURY OF FORMAL TRAINING PROGRAMS. THEY ARE EFFECTIVE AT ONE-ON-ONE APPRENTICESHIP TRAINING IN THE OLD AND TRADITIONAL CONCEPT OF SKILLS TRAINING.

3. WHERE SHORTAGES OF SKILLED LABOR ALREADY EXIST, THERE ARE USUALLY SERIOUS BACKLOGS AND CONCURRENT PRESSURES ON PRODUCTION. SMALL MANUFACTURERS ARE RELUCTANT TO TAKE JOURNEYMEN OFF THEIR REGULAR DUTIES TO TRAIN NEW EMPLOYEES BECAUSE THIS SLOWS PRODUCTION AND LOWERS PRODUCTIVITY.

THE PRESENT SKILLS SHORTAGE IS LIVING PROOF THAT EXISTING PROGRAMS DESIGNED TO ENCOURAGE TRAINING HAVE FAILED TO DO THE JOB.

1. PROGRAMS FUNDED THROUGH THE DEPARTMENT OF LABOR, SUCH AS CETA, HAVE GRADUALLY BECOME SOCIAL UPLIFT IN ORIENTATION. THEY ARE DESIGNED TO TRAIN THE ECONOMICALLY DISADVANTAGED FOR JOBS THAT MAY OR MAY NOT EXIST, RATHER THAN DESIGNED TO IDENTIFY AND TRAIN THOSE QUALIFIED FOR THE HIGH-PAYING, BUT EQUALLY DEMANDING, AVAILABLE SKILLED JOBS. THE FORMER MAY HAVE SOCIOLOGICAL VALUE, BUT THE LATTER MAKES ECONOMIC SENSE. A SKILLED WORKER IN THE TOOLING AND MACHINING INDUSTRY, THE HIGH TECHNOLOGY ELECTRONICS INDUSTRY, AND OTHERS NEED CERTAIN MATHEMATICAL SKILLS AND LOGICAL APTITUDES, PHYSICAL DEXTERITY, PATIENCE, DETERMINATION, PERSEVERANCE, AND IMAGINATION. THEY ARE PERHAPS THE MOST HIGHLY SKILLED WORKERS IN AMERICA TODAY.

OUR INDUSTRY HAS RUN A CETA-FUNDED PRE-EMPLOYMENT PROGRAM FOR 18 YEARS. IT HAS LONG BEEN CONSIDERED ONE OF THE BEST JOINT EFFORTS BETWEEN INDUSTRY AND GOVERNMENT. IF IT HAD BEEN ADEQUATELY FUNDED AND CONTINUED OPERATING UNDER THE ORIGINAL MANPOWER DEVELOPMENT AND TRAINING ACT, IT COULD HAVE DONE A TREMENDOUS AMOUNT TO ALLEVIATE THE SHORTAGE THAT NOW EXISTS. HOWEVER, EVEN IF WE WERE FUNDED AT HIGHER RATES UNDER THE CETA CRITERIA, THE

EFFECTIVENESS AND ACCEPTANCE OF THIS PROGRAM WOULD CONTINUE TO DETERIORATE UNTIL THE GOVERNMENT RECOGNIZES THAT BASIC APTITUDE, RATHER THAN SOCIO-ECONOMIC BACKGROUND, IS THE SINGLE MOST IMPORTANT DETERMINANT OF POTENTIAL SUCCESS FOR HIGHLY SKILLED JOBS. BUSINESS MUST BE PERMITTED TO RECRUIT PEOPLE WITH PROPER QUALIFICATIONS RATHER THAN BE FORCED TO RECRUIT PERSONS WHO ARE IN MANY CASES UNTRAINABLE FOR HIGHLY SKILLED PROFESSIONS.

2. TAX CREDIT PROGRAMS, SUCH AS THE TARGETED JOBS TAX CREDIT, SUFFER FROM THE SAME MISDIRECTION. IN NO WAY ARE THEY AIMED AT IDENTIFYING AND TRAINING THE RIGHT KIND OF INDIVIDUALS FOR THE AVAILABLE COMPATIBLE JOBS THAT EXIST TODAY. LEGISLATORS HAVE NOT FACED A CENTRAL TRUTH. NOT EVERYONE FROM ANY POPULATION HAS THE APTITUDE REQUIRED TO BECOME A HIGHLY SKILLED MACHINIST. MANY OF THE ECONOMICALLY DISADVANTAGED ARE ALSO OFTEN EDUCATIONALLY DISADVANTAGED. AS A RESULT, A SMALLER PROPORTION OF THIS POPULATION POSSESS THE APTITUDES TO BE EFFECTIVE IN THIS AND OTHER HIGHLY SKILLED PROFESSIONS. ANY PROGRAM WHICH IMPOSES INFLEXIBLE RESTRICTIONS ON THE POPULATION WHICH CAN BE TRAINED OR RESTRICTIONS ON TECHNIQUES USED TO IDENTIFY THOSE WHO CAN BE TRAINED, WILL ULTIMATELY FAIL AS A SOLUTION TO THE SKILLS SHORTAGE IN THIS COUNTRY.

3. VOCATIONAL EDUCATION PROGRAMS HAVE SUFFERED FROM SOME OF THE SAME TENDENCIES. IN ADDITION, THERE HAS BEEN A LACK OF

COMMUNICATION BETWEEN THE VOCATIONAL COMMUNITY AND THE EMPLOYER GROUPS. PRESENTLY, THERE SEEMS TO BE A TREND TOWARD BETTER COOPERATION BETWEEN THE 2 GROUPS AND VOCATIONAL EDUCATION PROGRAMS SHOULD BE SUPPORTED TO ENCOURAGE THIS DESIRED CHANGE. HOWEVER, THIS WILL TAKE MANY, MANY YEARS AND SOLUTIONS TO THE PROBLEM ARE NEEDED NOW.

4. AN EVEN BROADER PROBLEM IS THE FAILURE OF PRIMARY AND SECONDARY SCHOOL SYSTEMS TO PROVIDE THE BASIC CORNERSTONE IN MATHEMATICS AND ENGLISH WHICH ARE THE BASIC TOOLS OF ALL BUSINESSES, ESPECIALLY OURS. THE PROBLEM IS GETTING WORSE, RESULTING IN A SMALLER POOL OF QUALIFIED CANDIDATES EACH YEAR.

OUR INDUSTRY HAS BEEN VIEWING THE PROBLEM FOR SOME TIME, SEEKING SOME EFFICIENT, LOGICAL, PRACTICAL, AND SIMPLE APPROACH TO THE SHORTAGE OF SKILLED LABOR IN THE U.S. WE CONCLUDE AND RECOMMEND THE FOLLOWING TWO COURSES TO SOLVE THE SKILLS SHORTAGE:

1. JOINT INDUSTRY/GOVERNMENT TRAINING PROGRAMS SHOULD BE CONTINUED AND SHOULD BE EXPANDED, BUT THE GOAL AND OPERATION SHOULD BE RETURNED TO THOSE OF THE ORIGINAL MANPOWER DEVELOPMENT AND TRAINING ACT OF 1962. THE SPECIFIC PURPOSE OF MDTA WAS TO IDENTIFY MANPOWER SHORTAGES AND FUND PROGRAMS WHICH WOULD TRAIN QUALIFIED PEOPLE, "AS QUICKLY AS IS REASONABLY POSSIBLE IN ORDER THAT THE NATION MAY MEET THE STAFFING REQUIREMENTS OF THE STRUGGLE FOR FREEDOM." THIS IS A CONSIDERABLY DIFFERENT APPROACH THAN

IS PRESENTLY EMBODIED UNDER EXISTING CETA PROGRAMS. IT MAY BE THAT THE ORIGINAL PHILOSOPHY OF MDTA COULD BE APPLIED TO CETA BY ADMINISTRATIVE ACTION. WE ARE SURE THE SECRETARY OF LABOR WOULD APPRECIATE SUGGESTIONS FROM THIS COMMITTEE. IT MAY BE, HOWEVER, THAT LEGISLATION WOULD BE NECESSARY.

2. A SPECIALIZED SKILLS TRAINING TAX CREDIT, AVAILABLE TO THOSE CRITICAL INDUSTRIES WITH A DEMONSTRABLE SHORTAGE OF HIGHLY SKILLED LABOR, SHOULD BE ENACTED. THE AMOUNT OF THE TAX CREDIT SHOULD BE CLOSE TO THE TRUE COST OF TRAINING, WHICH IS QUITE HIGH, IN ORDER TO OFFSET THOSE COSTS AND THE LOSS OF PRODUCTIVITY WHICH OCCURS DURING THE TRAINING PROCESS. THE TAX CREDIT SHOULD BE APPLIED ONLY TO NEW APPRENTICES AND ONLY TO INDUSTRIES OR PROFESSIONS HAVING A CERTIFIABLE SHORTAGE SHOULD BE ELIGIBLE.

TWO PIECES OF LEGISLATION HAVE BEEN OFFERED WHICH ADDRESS THIS PROBLEM. THE JOB CREATION TAX ACT OF 1981, INTRODUCED BY CONGRESSMAN NOWAK AND COSPONSORED BY CONGRESSMAN MARRIOTT, WOULD ADD A "BONUS CREDIT" TO A "BASE CREDIT" TO ENCOURAGE THE HIRING OF EMPLOYEES IN INDUSTRIES EXPERIENCING A SHORTAGE OF SKILLED LABOR. UNDER THE BILL, ALL EMPLOYERS WOULD BE ALLOWED A CREDIT, WHICH COULD AMOUNT TO AS MUCH AS $3,000 DURING THE FIRST YEAR OF EMPLOYMENT PER EMPLOYEE. IN ADDITION TO THAT AMOUNT, A BONUS CREDIT OF AS MUCH AS $2,400 WOULD BE ADDED FOR EACH OF TWO YEARS IF THE EMPLOYEE IS RECEIVING SKILLS TRAINING AND IN AN industry with labor shortages. A similar bonus credit applies to employers in distressed areas. Thus, a company could recover a significant portion of the cost of training a skilled worker. It would total $5,400 in the first year and $2,400 in the second year. The Nowak/Marriott bill, H.R. 3726, is one of the first bills to recognize the seriousness of the skilled labor shortage in this country and the economic differentials involved in training the highly skilled.

Subsequently, Congressman Don Bailey introduced the Critical Industry Reindustrialization Tax Act of 1981. This legislation provides a 50 percent credit of first year wages and a 30 percent credit of second year wages provided to the employer of any individual in a skills training program in an industry with a shortage of skilled labor. The additional advantage of this approach is that it automatically adjusts for inflation in wage rates.

Thank you.

○